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Preface

We would like to present, with great pleasure, the inaugural volume-4, Issue-6, June 2018, of a scholarly journal, *International Journal of Environmental & Agriculture Research*. This journal is part of the AD Publications series *in the field of Environmental & Agriculture Research Development*, and is devoted to the gamut of Environmental & Agriculture issues, from theoretical aspects to application-dependent studies and the validation of emerging technologies.

This journal was envisioned and founded to represent the growing needs of Environmental & Agriculture as an emerging and increasingly vital field, now widely recognized as an integral part of scientific and technical investigations. Its mission is to become a voice of the Environmental & Agriculture community, addressing researchers and practitioners in below areas

Environmental Research:

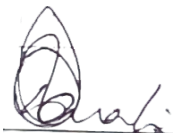
Environmental science and regulation, Ecotoxicology, Environmental health issues, Atmosphere and climate, Terrestric ecosystems, Aquatic ecosystems, Energy and environment, Marine research, Biodiversity, Pharmaceuticals in the environment, Genetically modified organisms, Biotechnology, Risk assessment, Environment society, Agricultural engineering, Animal science, Agronomy, including plant science, theoretical production ecology, horticulture, plant, breeding, plant fertilization, soil science and all field related to Environmental Research.

Agriculture Research:

Agriculture, Biological engineering, including genetic engineering, microbiology, Environmental impacts of agriculture, forestry, Food science, Husbandry, Irrigation and water management, Land use, Waste management and all fields related to Agriculture.

Each article in this issue provides an example of a concrete industrial application or a case study of the presented methodology to amplify the impact of the contribution. We are very thankful to everybody within that community who supported the idea of creating a new Research with *IJOEAR*. We are certain that this issue will be followed by many others, reporting new developments in the Environment and Agriculture Research Science field. This issue would not have been possible without the great support of the Reviewer, Editorial Board members and also with our Advisory Board Members, and we would like to express our sincere thanks to all of them. We would also like to express our gratitude to the editorial staff of AD Publications, who supported us at every stage of the project. It is our hope that this fine collection of articles will be a valuable resource for *IJOEAR* readers and will stimulate further research into the vibrant area of Environmental & Agriculture Research.

Mukesh Arora
(Editor-in Chief)



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(Managing Editor)

Fields of Interests

Agricultural Sciences	
Soil Science	Plant Science
Animal Science	Agricultural Economics
Agricultural Chemistry	Basic biology concepts
Sustainable Natural Resource Utilisation	Management of the Environment
Agricultural Management Practices	Agricultural Technology
Natural Resources	Basic Horticulture
Food System	Irrigation and water management
Crop Production	
Cereals or Basic Grains: Oats, Wheat, Barley, Rye, Triticale, Corn, Sorghum, Millet, Quinoa and Amaranth	Oilseeds: Canola, Rapeseed, Flax, Sunflowers, Corn and Hempseed
Pulse Crops: Peas (all types), field beans, faba beans, lentils, soybeans, peanuts and chickpeas.	Hay and Silage (Forage crop) Production
Vegetable crops or Olericulture: Crops utilized fresh or whole (wholefood crop, no or limited processing, i.e., fresh cut salad); (Lettuce, Cabbage, Carrots, Potatoes, Tomatoes, Herbs, etc.)	Tree Fruit crops: apples, oranges, stone fruit (i.e., peaches, plums, cherries)
Tree Nut crops: Hazlenuts. walnuts, almonds, cashews, pecans	Berry crops: strawberries, blueberries, raspberries
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Livestock Production	
Animal husbandry	Ranch
Camel	Yak
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Goats	Poultry
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Freshwater prawn farm	Integrated Multi-Trophic Aquaculture
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Dairy Sheep	Water Buffalo
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Silvopasture	Christmas tree cultivation
Maple syrup	Forestry Growth
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Hay & Silage/Forage equipment	Milking equipment
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Agricultural buildings	Storage

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Table of Contents

Analysis of Determinant Factors to Loan Repayment among Broiler Farmers in Enugu State, Nigeria

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Abstract— *Analysis of loan repayment among rice farmers in Enugu State, Nigeria was studied using one hundred and eighty respondents. These respondents were selected using multi stage sampling procedure and purposive selection procedure. The objectives of the study were to describe the socio-economic characteristics of the broiler farmers, identify the various broiler management practices the farmers put their credit into, assess the determinant factors influencin loan repayments among the farmers and identify the constraints to loan repayment by the farmers in the study area. Structured questionnaire was used to collect information for the study. Data collected were analyzed using descriptive such as frequency distribution table and percentage responses, inferential statistics such as Logit model and factor analysis. The results of the study indicated that the sampled farmers were youthful, females, married, and had large household size and farming experience of above 11 years. Also, microfinance and commercial banks were the major sources of credit to the farmers. In addition, the major uses the credit was put into by the farmers were in purchasing feeds and buying of drugs and vaccines. The determinant factors to rice farmers' loan repayment ability were household size, extension services, membership of organization, farming experience, educational level and off-farm income. The constraints to the farmers' ability to repay their loan were high interest rate, low productivity, high collateral, poor loan assessment and changes in bank policy changes. The need to enhance the farmers' access to training, off- farm income and the need to give rebate to farmers that repay their loans at appropriate time were recommended.*

Keywords— Analysis, Loan, Repayment, Broiler, Farmers, Enugu State, Nigeria.

I. INTRODUCTION

The repercussions of animal protein origin deficiency to the lives of the people particularly children under the ages of five years old and pregnant women in rural areas of sub- Saharan Africa is of major concern to policy makers, researchers and government (FAO, 2015). The high prices of animal protein particularly conventional animals like cattle, sheep and goat meats has made its' consumption to be more restricted to the rich, while the less privileged ones seldom has it in their menus (Kughur, *et al*.2012). This setting is capable of hampering the millennium development goal of meeting the average of 120kg animal protein intake per day as recommended by FAO as against freighting low (3.24g) that is often reported in the developing countries (Kusina and Mhlanga, 2000; Ume, *et al* 2016). Nevertheless, the low intake of protein is capable of predisposing mostly these vulnerable to weight loss, weakness, fatigue, poor appetite and anemia (FAO, 2015). Among the economy livestock that is capable of bridging the wide gap in dietary protein intake in most developing countries is broiler, a sector of poultry (Nwaru and Nwaeke, 2008; Ume, *et al;* 2013). The intrinsic features of broiler which endeared it as a veritable way of alleviating animal protein deficiency in Saharan Africa; include having fast growth rate, high feed conversion efficiency, ability to be marketed at different ages, low production cost per unit in relative to other types of livestock, has tender meat and commonly used in ceremonies compared to other birds and has short production circle (Kughur, *et al*. 2012; Ezeano, *et al*. 2017). Furthermore, it is palatable and generally acceptable across nearly all cultural and religion boundaries , early maturity compares to most breeds of livestock and make economic proceeds within comparatively short time of about 10-12 weeks (FAO, 2015).Studies inferred that broiler constitutes more than 18% of animal proteins consumed in urban areas of Nigeria with more than 28% also produced in same urban area (Kusina and Mhlanga, 2000, Nwaru and Nwaeke, 2008). Literature showed that broiler farmers are faced by myriads of problems, include lack of skills and equipment to produce, high cost of feed, high cost of day old chicks, fluctuation in market prices, poor breeds of day old chicks, high cost of building materials, high cost of labour and access to credit (Ume, *et al;* 2013; Ezeano, *et al;* 2017).

Credit as asserted by Oladeebo and Oladeebo, (2008) is the ability to acquire goods and services or money in swap for pledge for payment in future. The important of credit to agricultural development cannot be overemphasized. Agricultural credit is

capable of improving the growth of agriculture through use of new technologies, strengthen the position of the farmers in dispensing his/her livestock, cushioning the effects of seasonal price disparity and enhanced bargaining power, adopt improved agricultural practices and thus boost production ethics, improves output and advances standard of living of people by breaking vicious cycle of poverty(Duong and Izumida, 2002, Chaudhary and Ishfag, 2003), enhances access to improved inputs, improves consumption and expenditure especially during off-season period, boast access to basic social service, boast farmers' welfare through limitless access to vital social services and improves high production efficiency for output maximization (Chloupkova and Bjønskov, 2001; De-Graft, and Addo, 2011). Studies showed that the farmers apart from their personal savings, formal institution has been the major access to credit as their activities are monitored by government (Lawal, *et al*. 2009; Osuntogun, 2012) and to debunk shylock loan often associated with informal sector lending institution (De-Graft and Addo, 2011). The prominent among formal credit lending institutions available to the farmers were Agricultural Credit Guarantee Scheme (ACGS), the Nigeria Agricultural and Cooperative Bank (NACB), microfinance and commercial banks (Lawal, *et al*; 2009; Ibrahim and Aliero, 2012). In addition, the informal sources available to the farmers were money lenders, personal savings, friends and Rotating Savings and Credit Associations (ROSCAs) (Anozie *et al;* 014).The low repayment of formal institution among farmers have been problematic that most formal sector lending institution often decline in lending to such farming class through use of an uphill conditions for acquisition and use of the loan (Osuntogun, 2012). However, the default or delinquency in repayment of agricultural credit by the farmers could be linked to the inherent nature of agriculture as relates to risks and uncertainties in output production and prices, resulting in poor economic returns to farming households (Chloupkova and Bjønskov, 2001). Research show that the determinants of loan repayment defaults in rural banking and semi financing institutions among low income and individual-based lending schemes can be checkmated through direct monitoring, regular repayment schedules, and the uses of non-refinancing threats without requiring collateral and without using group lending contracts that feature joint liability (Chaudhary and Ishfag, 2003).

Nevertheless, the repayment of loans is very beneficial as it helps to ensure the recycling of money to other farmers, as poor repayment has the probable of lending agencies charging high interest rate and high processing charge to the borrowers in order to keep afloat in the business, thus repelling other possible beneficiaries (Chaudhary and Ishfag, 2003). It is paramount to state that the borrowers alone cannot be held accountable for loan defaults as it is imperative to scrutinize the level to which both borrowers and leaders abide by the loan agreement and the nature of the duties, responsibilities and duties of both parties as revealed in the plan of the Credit programme (Kashuliza, 1993; Afolabi, 2010). However, in order to empirically determine loan repayment among clients, a study of this nature becomes imperative as there is paucity of information to that effect in the study area. Specifically, the objectives of the study are to;

i. describe the socio-economic characteristics of the broiler farmers,
ii. identify the various loan sources used by the farmers,
iii. identify the various broiler management practices the farmers put their loan into,
iv. assess the determinant factors influencing loan repayments among the farmers,
v. identify the constraints to loan repayment by the farmers in the study area.

II. RESEARCH METHODOLOGY

Enugu State is in south east Nigeria and located between latitudes 6°30/ N and 7°10/N of Equator and longitudes 6°35/ E and 7°30/E of Greenwich Meridian. Enugu State has eighteen Local Government Areas with three agro- political zones, namely; Enugu west, East and South. The state has an estimated population of about 4, 1671 million people (NPC, 2006). The state has a land area of 16,727 square km^2. It is bounded in the west by Anambra State, in the West by Abia State, in the South by Imo State and in the North by Benue State. Enugu State is known to be characterized of wet climatic zone with a rainfall of about 1800mm to 2500mm per annum, temperature range of 29^0C to 35^0C and relative humidity of 68%. The state is agrarian and other non agricultural activities engaged by the people, include barbing, hair dressing salon, vulcanize and petty trading.

A multi-stage sampling procedure and purposive sampling were employed to select agricultural zones, communities', villages and respondents. In stage 1, the three agricultural zones of the state (Enugu North, Enugu South and Enugu East) were purposively selected. The purposive selection of the agricultural zones was based on abundant production of broiler because of nearness of broiler feed raw materials and high broiler markets because of presences of hotels, bars, restaurants and high institutions (Ume, et al 2013). In the second stage, four Local Government Areas (LGAs) were purposively selected from each of the zones on the basis of their levels of broiler production. The selected LGAs were; Nsukka, Uzouwani and Udenu were selected from Enugu North; Nkanu East, Nkanu West, and Enugu south from Enugu West, while Oji River, Awgu and Anniri from Enugu East. The third stage involved a random selection of four communities from each of the nine selected Local Government Areas. This gave a total of thirty six communities. In stage four, a market was selected from each of the thirty six communities. Finally five broiler farmers were randomly selected from each of the thirty six markets and a

total of one hundred and eighty respondents were selected for detailed study. Questionnaire was administered to the respondents in order to gather data needed for the study. The data were analyzed using descriptive such as frequency distribution table and percentage responses, inferential statistics such as Logit model and factor analysis.

III. MODEL SPECIFICATION

3.1 Logistic Regression

The study adopted the logistic regression to assess the factors that determine the broiler farmers' ability to repay loan. The use of logit model for this analysis is consistent with the literature on loan repayment (Kedir, 2007) which describes the process of loan repayment as taking on a logistic nature. The response variable was binary, taking values of one if the farmer repays the loan and zero otherwise. However, the independent variables were both continuous and discrete. The logistic distribution (logit) has advantage over the others in the analysis of dichotomous outcome variable in that it is extremely flexible and easily used from mathematical point of view with a meaningful interpretation. The parameter estimates of the model are asymptotically consistent and efficient. The binary logistic model does not make the assumption of linearity between dependent and independent variables and does not assume homoskedasticity. Another advantage of using the logit model is that it does not require normally distributed variables and above all, the logit model is relatively easy to compute and interpret. Hence, the logistic model is selected for this study. The probability that a farmer will adopt at least one improved cassava variety was postulated as a function of some socioeconomic and demographic characteristic factors given in Table 1. Following Kashuliza, (1993), the cumulative logistic probability model which is estimated is econometrically specified as:

$$Pi=F(Zi)=F(\gamma)+\sum i\lambda iXi=11+e-ZiPi=F(Zi)=F(\gamma)+\sum i\lambda iXi=11+e-Zi \quad (1)$$

Where P_i is the observed response for the i^{th} observation of the response variable P. It is the probability that a farmer will repay the loan or not given X_i; P_i =1 for farmers that repay loan and P_i = 0 for farmers that do not repay loan; e denotes the base of natural logarithms, which is approximately equal to 2.718; X_i represents the explanatory/ independent variables, associated with the i^{th} individual, which determine the probability of adoption (P); λ_i and γ are parameters to be estimated. The function, F may take the form of a normal, logistic or probability function. $\boldsymbol{Z_i}$ is the cumulative density function of $\boldsymbol{P_i}$ (probability that a farmer will adopt at least one improved cassava variety).

$$1-Pi=11+eZi1-Pi=11+eZi \quad (2)$$

Logit model could be written in terms of the odds and log of odds, which enables one to understand the interpretation of the coefficients. The odds ratio implies the ratio of the probability (P_i) that a farmer repays the loan, to the probability ($1-P_i$) that the farmer do not repay the loan.

If the disturbance term U_i is taken into account, the logit model becomes

$$Zi=Y+\sum i=1m\lambda iXi+UiZi=Y+\sum i=1m\lambda iXi+Ui \quad (3)$$

The empirical model is stated explicitly as:

$$Y_i = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4 + \beta_5 x_5 + \ldots + \beta_{11} x_{11} + \beta_{12} x_{12} + \beta_{13} x_{13} + \beta_{14} x_{14} + Ui \quad (4)$$

Where Yi =loan repayment ability (able to pay =1, 0 otherwise);, *x1* = Age (years); *x3* = Educational level (Years); *x4* = Marital status (Married = 1, 0 otherwise); x_5 = Year of Credit experience (years); *x6* = Farm size (Hectares); x_7= Household size (No), x_8 = Extension service (Yes = 1, 0 if otherwise),

3.2 Factor analysis Model

Factor analysis model was employed to identify the constraints experienced by broiler farmers in loan repayment. The principal component factor analysis with varimax –rotation and factor loading of 0.3 was used. The constraints observed by farmers were grouped into four factors using varimax rotation and factor loading of 0.30. The principal component factor analysis model is stated thus;

$$C_1 = a_{11} f_1 + a_{12} f_2 + \text{----------} a^1 n f_n \quad (5)$$

$$C_2 = a_{21} f_2 + a_{22} f_{2+} \text{----------} a^2 nfn \quad (6)$$

$$C_3 = a_{31} f_3 + a_{32} f_2 + \text{----------} a^3 n f_n \quad (7)$$

$$C_3 = a_{41} f_4 + a_{42} f_2 + \text{----------} a^4 n f_n \quad (8)$$

$$C_n = a_{n1} f_3 + a_{n2} f_2 + \text{----------} a^n n f_n \quad (9)$$

Where

$C_1 = c_n$= observed variable /constraints to farmers' repayment of loan pdts
$a_1 = a_n$ = factor loading or correlating coefficients
$f_1 = f_n$ =unobserved underlying challenging factors facing farmers' repayment of loan

TABLE 1
DESCRIPTION OF VARIABLES USED IN THE LOGISTIC MODEL

Variable	Measurement	*A priori* expectation
Age	Age of the household head (years)	-
Educational level	Years of school attendance (years)	+
Household size	Number of dependents (number of people)	-
Farming experience	Number of years of farming (years)	
Farm size	Size of the farm (Flock size)	
Extension service	Visit from extension workers (1 yes, if no)	-
Marital status	Married; 1, single; 0	
Membership of Organisation	Membership of organ.; 1; otherwise, 0	+
Off farm income	Income from outside the farm, 1; otherwise; 0	+

The Socio-economic Characteristics of the Respondents is shown in Table 2

TABLE 2
DESCRIBE THE SOCIO-ECONOMIC CHARACTERISTICS OF THE RESPONDENTS

Variable	Frequency	Percentage
Age		
31 – 40	110	61.1
41 – 50	40	22.2
51 – 60	18	10
Above 61	12	6.6
Marital Status		
Married	120	66.7
Single	50	27.8
Widow	10	5.5
Divorced	-	-
Educational Level		
No Formal Education	40	22.2
Primary	80	44.4
Secondary	40	22.2
Tertiary	20	11.1
Gender		
Male	60	33.3
Female	120	66.6
Household size		
1 – 10	140	77.7
11 – 21	30	16.6
22 – 32	10	5.5
Farming Experience		
1 – 10	88	48.9
11 – 21	72	40
22 – 32	15	8.3
33 – 42	5	2.8
Membership of Organization		
Access	80	44.5
Non access	100	55.5
Extension Contact		
Access	60	33.3
Non access	120	66.7
Off farm income		
Access	160	88.9
Non Access	20	11.1

Source; Field Survey; 2017

IV. RESULTS AND DISCUSSION

Table 1 showed the distribution of respondents according to socio-economic characteristics. The majority (61.1%) of the respondents were within the age range of 31 - 40 years, whereas 22.2% and **10%** were within the age brackets of 41 – 50 and 51 - 60 years respectively. The implication is that youths dominated the sampled farmers in the study and according to literature, this age class has common features of being motivational, risk averse and adoptive individual for enhanced production and less prone to loan defaulting (Ibrahim and Aliero, 2012). However, this finding contradicted the works of Njoku, (1997) who opined that aged people are more trust worthy to live up to their promises of loan repayment than younger ones .

Furthermore, 66.66% of the respondents were females, while males accounted for 33.34% of the total respondents . The high proportion of women in the business could be ascribed to the fact that women are better in animal husbandry management compare to male counterpart. Such good management attribute could help to curtail maximally mortality in the flock for higher production, thus improved chances of repaying such loan (Adam, 1998). The findings of Roslan and Karim, (2009) contradicted the above finding. They were of the view that males have more access to land (as security for loan acquisition) and other productive inputs than women, which could aid them in boasting their production and productivity for more likelihood of their loan repayment.

Table 2 revealed further that most of the respondents were married and accounted for about 66.7% of the total sampled farmers. This was followed by single (27.8%) and widowed (5.5%). Married people as asserted by Anozie, *et al.* (2014) are likely to incur extra expenditures for family livelihood from the loan, thereby threatening their loan repayment ability. Also, majority (77.7%) of the respondents had household sizes of 1- 10, while the least (5.5%) had 22 – 32 people. Large household size could be a source of cheap family labour especially during peak of farming activities when cost of hired labour is high. In this aforementioned scenario, such household head will have high propensity to save lots of money that could have been used for hired labour and use it offset his/her loan (Kedir, 2007). In contrary, Ibrahim and Aliero, (2012) opined that large family size that comprises more of dependent population, the household head have more probable of being loan defaulters as such loan are often diverted to family welfare upkeep (Adams, 1998).

In addition, majority (77.8%) of the respondents were educated, while only 22.2% were not educated. An educated farmer has the potentials of enhancing their farm productivity and economic status through the adoption of new technologies. The money accruing from the sales of hi/her outputs could be used to compensate for the loan (Osuntogun, 2012).

The Table moreover showed that 48% of the respondents had farming experience below 11 years, while 52% had above 11. Studies showed that the years of farming experience of farmer increases as age of the farmer increases and this correlates positively with productivity. This situation is capable of enhancing the farmers' loan repayment ability as lots of money will be realized through sales of farm outputs (Kashuliza, *et al* 1993). In addition, the number of years of farmer's farming experience according to Mupa, (2004) compares with his/her level of setting realistic goals geared towards high production, which could tantamount to higher prospect of loan repayment at right time as more funds become available to the farmer (Mpuga, 2004).

Besides, 55.5% of the respondents were not members of organization, while 45.5% were members. Membership of organization in form of cooperatives, young farmers' club and age grade helps to ensure members' access to credit and productive inputs. This could guarantee higher farm productivity and more odds of having fewer defaulters in loan repayment. Also, as reported by Oladeebo and Oladeebo, (2008) **c**ooperative societies possess some elements of social networks that are vital for enhancing group dynamics, financial support and farm productivity, hence could improve their loan repayment odds. The Table as well revealed that 66.7% of the respondents had no access to extension services and only 33.3% had access. Extension services help in dissemination of agricultural technologies to farmers and enhancing farmers' access to productive inputs (such as credit, fertilizer and agrochemicals) for higher outputs, hence curtailing their possibility of loan default (Aliou, and Zeller, 2011). As well, 88.9% of the respondents engaged in off -farm income, while very low proportions of sampled farmers (11.1%) did not participate. Off farm income is source of income for enhancing households' economies through greater access to food, thus giving room for savings aimed at repayment of the loan borrowed (Owuor, 2009).

Table 3 showed the distribution of various sources of credit options available to farmers.

TABLE 3
DISTRIBUTION OF RESPONDENTS ACCORDING TO VARIOUS CREDIT SOURCES

Variable	Frequency	Percentage
Microfinance	124	68.8
Commercial Bank	98	54.4
Money Lender	78	43.3
Personal saving	86	47.7
Friends and relations	62	3.4

Source; Field Survey; 2017

The credit acquired from microfinance was the highest (68.8%). The ease farmers borrow money from microfinance banks without collateral could be attributed to the high patronage (Afolabi, 2010). This was followed by commercial banks (54.4 5%). The benefaction of commercial banks by respondents could be linked to ability of the bank to meet up with clients' amount of money demanded as loan (Sharma, 2000). The informal sources of credits as shown in Table 3 were personal savings (47.7%), money lenders (43.3%) and friends and relations (3.4%).

Table 4 showed the uses the respondents put the loan into. Majority (77.7%) of the respondents put the loan into purchasing feeds for feeding the birds. Poultry feeds are very expensive and constitutes over 45% of total cost of broiler production. This could be because of high cost of grains and other materials use in broiler feed formulation (Ume, *et al*; 2013).

In addition, 72% of the sampled farmers used their loan for buying drugs and vaccines for treatment of diseases and pests in their broiler farms. Medication is very necessary in curtailing mortality in poultry management, especially for broiler production that is very fragile (Ume, *et al; 2017*).

Also, 37.7 % of the respondents employed their credit to purchase day old chicks. A good breed of day old chicks as asserted by Kughur, *et al;*(2012) is important for quick growth and to ensure that the birds meet up with the targeted markets in order to ensure high profitability.

TABLE 4
DISTRIBUTION OF RESPONDENTS ACCORDING USES RESPONDENTS PUT CREDIT INTO

Variable	Frequency	Percentage
Building of poultry house	54	30
Buying drugs and vaccines	130	72
Purchasing day old chicks	68	37.7
Purchasing of feed	140	77.7
Marketing of the bird	23	12.7
Hiring of Labour	67	37.2

Source; Field Survey, 2017
***Multiple Responses**

TABLE 5
DETERMINANT FACTORS INFLUENCING LOAN REPAYMENTS AMONG BROILER FARMERS.

Variable	Estimated coefficient	Standard Error	Z - ration	p>IZI
Constant	4.653	1.234	3.771***	0.540
Age	- 4.654	2.230	- 2.086*	0.108
Marital status	0.276	0.376	0.734	0.008
Gender	0.654	0.765	0.854	0.026
Off farm income	0.456	0.362	1.260*	0.005
Educational Level	4.074	1.045	3.897***	0.340
Farming Experience	3.006	1.027	2.927**	0.135
Membership of organization	2.546	0.538	4.750***	0.032
Extension Services	4.112	1.432	2.872**	0.430
Household size	3.132	1.112	2.817**	0.027

Log likelihood -118.4378
Wald chi2 (12) 36.02
Pseudo R2 0.1317
Cases predicted correctly (%) 73.6

Source: Field Survey, 2017, ***, **, * Significant at 1.0%, 5.0% and 10.0% levels respectively

The coefficient of age of the farmer was significant at 5.0% level of significance and the sign of the coefficient showed an indirect relationship with loan repayment by farmers. This implies that aged farmers have high probability of loan default. The reasons could be that aged farmers are risk verse, decline in manual strength and non receptive to new innovations/technology, consequently resulting in their being more prone to loan defaults as they experience low farm production and productivity (Adeyemo, *et al*; 2007; Ezeano, *et al.* 2017). The findings of Foltz, (2004) disagreed with the above contention; they were of the view that age has direct relationship with technology adoption, which is stem from accrued information and knowledge obtained from years of observations and experimentations with various technologies in order to enhance their output. In addition, membership of organization coefficient was statistically significant and positive in determining loan repayment .Studies showed that cooperative helps to educate and training of her members, promote productive utilization of loans lent, investment in sound and profitable business ventures, leadership development, business and strategic plan development and financial management. This could enhance loan repayments ability of the members (Sharma, 2000, Foltz, 2004, Shah, *et al* 2008). This result is at variance with Olotomola, (2002) who obtained a negative relationship between membership of farmers association and loan defaults. The negative sign of the coefficient could be linked to very poor membership of organization by people. This condition is capable of making farmers to have less probability of loan repayment as they often lack the necessary inputs to boost their production frontier.

Expectedly, the coefficient of extension services was statistically significant and had positive effect on farmers' loan repayment ability. Extension services as asserted by Shah, *et al;* (2008) assist farmers in improving their farming methods and techniques through educational procedures. This facilitates in increasing farmers' production efficiency and income, and so improving their odds of loan repayment. This finding did not concur with Brehanu and Fufa, (2008), who reported negative relationship between extension services and loan repayment. The sign identity could be connected to among others inadequate motivation of extension agents/workers, inadequate subject matter specialist, non attendance to fortnightly meeting (FNT) block meeting by change agents, non-provision of adequate transportation and communication facilities; lacking of extension personnel and poor monitoring of extension agents (Ume, *et al;* 2016).These factors are capable of affecting the innovations dissemination to the farmers, resulting in low productivity, hence low repayment of loan could ensue (Pricisillia, 2011). Furthermore, the coefficient of Off-farm income was positive and significant at 10% level of probability. Off farm income as asserted by Oladeebo and Oladeebo, (2008) provides farmers with cash to invest in productivity-enhancing inputs and increasing the profitability of farming by increasing the availability of inputs and improving access to market outlets. It is general consensus among literature that farmers that have multiple streams of income have higher potential of loan repayment (Brehau and Fufa, 2000).

The coefficient of level of formal education attained also was significant at 1% level and the sign of the coefficient shows a direct relationship with loan repayment by farmers. Formal education and training enhance farmers' capabilities to comprehend and acknowledge technological innovations in economic activities which lead to increased and sustainable

agricultural production (Anozie, *et al*;2014). Studies revealed that people with good educational status are usually the choice of lending agencies as they have testimonial of being less defaulters (Olotomola, 2002). Contrary, Anozie, *et al* (2014) reported that the preference of educated people to "white collar job" as against farming, could result in low repayment as substantial amount of the credit is diverted into nonagricultural activities that may not be viable enough to produce the necessary dividends to repay the loan promptly. Also, the coefficient of household size had negative relationship with loan repayment and significant at 5% alpha level. Household size that are dominated with dependent population such as elderly, handicapped and children are likely to default in loan repayment as there is increase in per-capita consumption expenditure of farm households, leaving meager credit to be invested into the broiler business (Mpuga, 2004).

The varimax-rotated factors against loan repayment in the Study Area are shown in Table 6.

TABLE 6
VARIMAX-ROTATED FACTORS AGAINST LOAN REPAYMENT IN THE STUDY AREA

Variable	Factor 1	Factor 2	Factor 3	Factor 4
Lower productivity	0.250	0.341*	0.218	0.108
Character of the borrower	- 0.242	0.362*	0.122	0.231
Collateral	0.029	0.108	0.304*	0.226
credit scoring	0.321*	0.220	0.204	- 0.256
Changes in bank policy	0.312*	0.129	0.248	0.269
Poor loan assessment	0.326*	- 0.265	0.261	0.223
High interest rate	0.107	0.236	0.340*	0.144
Lack of supervision of projects	0.540*	0.204	0.255	0.109
Loan and income ratio	0.223	- 0.125	0.374*	0.154
Off Farm income	0.280	0.392*	0.216	0.208
Access to other source of credit	0.270	0.150	0.207	0.116
Method of repayment	0.003.	0.031	0.314	- 0.431
Human capital	-0.175	0.371*	0.0248	0.270
Market selling activities	0.263	0.007	0.0226	0.372*
Business Location	0.002	0.136	0.0104	0.391*
Size of the business	0.422	0.007	0.0233	0.053*

Source: computed from SAS 2017

Four factors were extracted based on the response of the respondents, Factor 1= lenders' characteristics factor, Factor 2 = borrowers‟ characteristics factor, Factor 3 = loan characteristics factor and factor 4 = business characteristics factor. Only variable with factor loading of 0.30 and above at 10% overlapping variance were used in naming the factors.This is line with the finding (Enete and Amusa, 2010) who are of the opinion that varibles with factor loading of less than 0.30 and variables that loaded more than one factor were discarded. Variables that loaded more than one factor like Access to other source of credit and method of loan repayment were discovered..In naming the factors Grosvenior, (2006) stated that each factor is given a denomination based on the set of variables or characteristics it is composed of. Constraints under the lender characteristics factor include lack of supervision of projects (0.0540), changes in bank lending policies (0.0340),and poor loan assessment (0.0326). The lack of supervision of projects could be as result of when update of customer information and borrowers circumstances is not done frequently as a result of the lending institution employees' inability to be close to their customers (Foltz, 2004, Kedir, 2007). Furthermore, this could arise through moral hazard by senior management, credit officers and borrowers, in form of lack of subjection of loan to normal objective credit assessment before disbursement. This may include extending credit to the personal business, personal friends and relatives among others. On the part of borrowers, moral hazard could occur when the borrowed funds are not put to the use for which they are meant for but rather the funds are diverted to other personal uses (Roslan and Karim, 2009). Besides, poor loan assessment of borrowers business by bank management according to Akwaa-Sakyi, (2013) has been responsible in the liquidating of many banks in early 2000 in Nigeria. To avert this problem, Oke et al. (2007) opined that when evaluating a small business for a loan, lenders must have in mind of seeing the two-year operating history, a stable management group, a desirable niche in the industry, a growth in market share, a strong cash flow, and an ability to obtain short-term financing from other sources as a supplement to the loan.

Also, the change in bank policies which could be in form of changes in bank lending policies in the form of changes in repayment schedule, nominal interest rate, grace period and moratorium as reported by Sharma, (2000) is capable of affecting loan repayment ability. On business credit scoring systems, Hananu, *et al*, (2015) opined that this system is used to envisage

from an applicant's characteristics whether the borrower is good (credit worthy) or bad (not creditworthy) risk, through among others looking at its past earnings or income projection of the business.

Variables that loaded under factor 2 (borrower characteristics) include; character of the borrower (0.0362), access to other credit sources (0.017) and off - farm income (0.0392). Bank management should screen the borrower's character and select the "good" borrowers from the "bad" borrowers and monitor the borrowers to avoid loan divertion from what they are main for(Von - Pischbe and Adam, 1980). Furthermore, there is need as affirmed by Adeyemo, et al (2007) to look at a borrower's past record and economic prospects to determine whether the borrower is likely to repay or not. Furthermore, off farm income, as opined by Haggblade, Hazell and Brown, (2009) could be farmers' diversification of their income sources, is capable of ensuring allowing them to spread risk and smoothen consumption over the year, thus could repay their credit promptly after offsetting vital family expenses . Also, borrower with health problems, have more odds of tampering with loan money to offset medical bill to the detriment of its repayment (Ume, *et al*.2013).

Variables that loaded under factor 3 (loan characteristics) include; interest rate of the loan (0.0340), collaterals associated with the loan (0.0304), loan and income ratio (0.374) and method of loan repayment (- 0.0431). Bank lending interest rate for the loan as observed by Wongnaa and Awunyo, (2013) is capable of swaying both intended borrowers' access to loan as well as their repayment capacity. This because when the high interest rate is add to sum of the principal amount, the borrower may default, as his or her business cash flow may not be able to foot the bill (Olotomola, 2002)

Furthermore, collateral is what borrowers provide in order to make credit lending less risky, as it gives loan security in case of defaults, which could be in form of social collateral used under group loans in the absence of physical collateral (Chaudhary and Ishfay, 2003; Ibrahim and Aliero2012; Anozie, et al, 2014) and use of proxy/ hidden collateral by MFIs offering individual loans (Duong and Izumida, 2003). Proxy collateral can help to evaluate the creditworthiness of a borrower as it is an indicator of income generating capability and ability to pay by the borrower (Odu, 2000). Thus, marketability, life, and riskiness according to Wongnaa and Awunyo, (2013) determine the attractiveness of various types of collateral to a lender and, hence, the amount of finances available to borrower. In addition, studies show that loan and income ratio affect loan repayment, as when the income of client is higher the loan he or she borrowed, the lower the defaulting rate and vice versa

The limiting factors under the business\farm characteristics factor 4 were low productivity (0.341), size of the business (0.3321), location of the business (0.0391) and market selling activities (0.371), Low productivity as affirmed by Duong, *et al;* (2010) could be as result of management not having sufficient experience and competence to run the business effectively, thus courting very high likelihood of loan default. Furthermore, low productivity could arisen because of risks associated with weather related problem (such as temperature, rainfall and relative humidity fluctuation), variability in soil quality, (Foltz, 2004) and natural hazard in form of flooding, fire disaster, pest and disease infestations, thunder lighting and among others (Osuntogun, 2012) which lead to low income and continually trapping them in a vicious cycle of poverty. More so, big business (0.055) if well managed with inputs well utilized will result in high production and productivity, consequently high income to offset their loans (Aliou, and Zeller, 2011). The findings of Shah, Khan, Jehanzeb and Khan, (2008) concurred to this assertion.

Moreover, on market selling activities, Duong and Izumida, (2003)remarked that when there is negative fluctuation in market prices of the clients' produce, the higher the probable of clients to default as profit volume will decline and vice versa.

Additionally, the business location items of access to production inputs, infrastructural facilities (such as electricity, pipe borne water and good road network) and customers' proximity could affect business performance positively and loan repayment ability (Njoku, 1997; Owuor, 2009). This means that any factor with variable loading of 0.3 and above are the important factor to be considered as serious factor militating against loan repayment in the study area.

V. CONCLUSION AND RECOMMENDATION

The sampled farmers were youthful, females, married, had large household size educated , membership of organization and farming experience of above 11 years. Also, microfinance and commercial banks were the major sources of credit to the farmers. In addition, the major uses the credit was put into by the farmers were in purchasing feeds and buying of drugs and vaccines. The determinant factors to rice farmers' loan repayment ability were household size, extension services, membership of organization, farming experience educational level and off farm income. The constraints to the farmers'

ability to repay their loan were high interest rate, lower productivity, lower productivity, collateral, poor loan assessment and changes in bank policy.

Based on the study, the following recommendations were proffered

1) There is need to improve on farmers' income and total farm sales, hence impelling loan repayment performance of borrowers.
2) Enhancing the borrowers' products marketability, financial management and accounting course through training in order to boast their business performances for reasonable profit to accrue for settlement of the loan they borrowed.
3) There is need to boost borrowers' repayment capacity by giving rebate to good borrowers.
4) Screening of potential borrowers by initially selecting those of their neighbors, friend and relative whom they believe to be capable of repaying the loan will help to minimize the loan defaulter's problem addressed in this study area.
5) Farmers can be made to improve on their repayment of credit by engaging in off- farm income support measures, which could serve as a panacea.

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Analysis of the Environmental Effect of Pig Production in Okigwe Local Government Area of Imo State, Nigeria

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Abstract— *The research was aimed at accessing environmental effect of pig production in Okigwe local Government Area of Imo state, Nigeria. The specific objectives of the study were to describe the socio economic characteristics of the respondents; identify the environmental effect of pig farming on the environs; identify the method of pig management and waste disposal methods among the respondents, determine the factors affecting the choice of waste disposal methods by respondents; and identify the constraints to wastes managements pig production in the study area. A total of 60 farmers were selected using purposive and multi stage random sampling techniques. The data were collected using questionnaire and secondary source. The data were analyzed using descriptive statistical such as percentage and frequency distribution table for objectives i, ii and iv. The objective iii was captured using multi nominal logit model. The results showed that most of the respondents were aged, males, educated and had large household size. More so, on the method of pig management, intensive method was the most popular. Additionally, open lagoon, dumping in the farm and store in the bag were the major methods for waste disposal in pig production. In addition, the result of the multinomial regression model on the choice of methods of wastes disposal showed that age of the respondents, farming experience and membership of cooperative organization were positive and significant. The major constraints to wastes management in pig production in the study area were poor access to credit, poor road network, water problem and high costs of labour. There is need to ensure farmers' access to credit, good road net work and water availability.*

Keywords— Analysis, Environmental effect, Pig production, Okigwe Local Government Area, Imo State, Nigeria.

I. INTRODUCTION

The economic and social benefits of livestock cannot be over emphasized (Bradshan *et al* 2004; FAO 2009). Livestock provide essential commodities and services to man in form of animal by-product (like meat, milk, hides and skins,) source of draught power, manure to enhance soil fertility and serves as a capital reserve available during hard times (Sudahmed, 2008; Tewe *et al;* 2009). Among the livestock that is used to alleviate man's animal protein defficiency particularly in rural areas of most developing countries of sub - Sahara Africa is pig (Tewe *et al; 2009)* The wide acceptability of pig production especially by small holder farmers could be attributed to its' high survival rate and ability to utilize a host of agro-industrial by-products and crop residues with little or no processing and at minimal cost (Sudahmed, 2008). Furthermore, pig is known to be prolific producer as it is capable of realizing 20 to 30 piglets from 2 or 3 liters per year and is capable of attaining slaughter weight of about 80 to 90kg in about 7 to 9 months under good management (Ajala *et al* 2007; John 2011).

The availability of Palm kernel cake, courtesy of NIPROC Company (A palm kernel processing company) has resulted in spontaneous rise in pig production in the study area. Here, pigs are raised in unconventional pens such as part of residential houses and uncompleted residential building without the course of maintaining the Environmental Protection Agency (EPA) regulation of 500 meters to residential houses. In effect, pig production is growing out of balance with the environment, resulting in environmental degradation which is primarily in form of air pollution (Sudahmed, 2008). Studies showed that air pollution in pig production arises from their excretion of excess dietary phosphorus and other minerals, inappropriate housing conditions which give rise to obnoxious odours and inappropriate manure and animal waste handling systems and their operations (Ajala *et al* 2007; John 2011; Hatfield 2008). To complicate the above scenario, the pig farmers in most of the developing countries catch on corruption and poor policy implementation of environmental protection by regulatory bodies in the region to recklessly dispose their animal's wastes in large open lagoon and other unacceptable methods without minding the associated repercussions to the environment and the environs (Okolo, 2011). For instance, the open air lagoon practice of waste disposal is capable of releasing green house gases (ammonia, nitrogen and methane) which is capable of raising the environmental temperature through destroying the lithosphere, hence releasing heat to the earth (John, 2007). Furthermore, the foul odour, flies and mosquitoes breed in manure pit are grassed continually to the neighbouring communities (Hatfield, 2008). Even, the noise from the animal is capable of causing noise – induced hearing loss,

cardiovascular effects in humans and an increased frequency of coronary artery disease (Young; 2009). In animals, noise can escalate the risk of death by altering predator or prey detection and avoidance, inhibit reproduction and navigation (Ajala *et al;* 2007). Studies showed that the effects of green house gases are respiratory problem, global warming, acidic rain, acidification, autrophication of the surrounding ecosystem, source of explosive and hearing losses (Rademacher 2009; John 2011). Furthermore, the flies and mosquitoes are capable of transmitting diseases such as cholera, dysentery, typhoid, and malaria and bilabial to man ([Powers *et al;* 2011)

However, environmental pollution by pig production can be minimized through adopting the following strategies, include seeking permit for construction of standard pig building from environmental Protection agency, adherence to 500 metres from pig pen to residential houses, appropriate waste disposal or handling system and proper precision feed management (Ewuziem, 2008). The waste disposal system could be in form of open lagoon; dumping in the farm, store in bag, heap waste and burn and sales of waste (John 2011; Powers *et al* 2011). The choice of the appropriate waste disposal method is affected by among other factors, the socioeconomic characteristics of the farmers (Ume, *et al;* 2018*)*

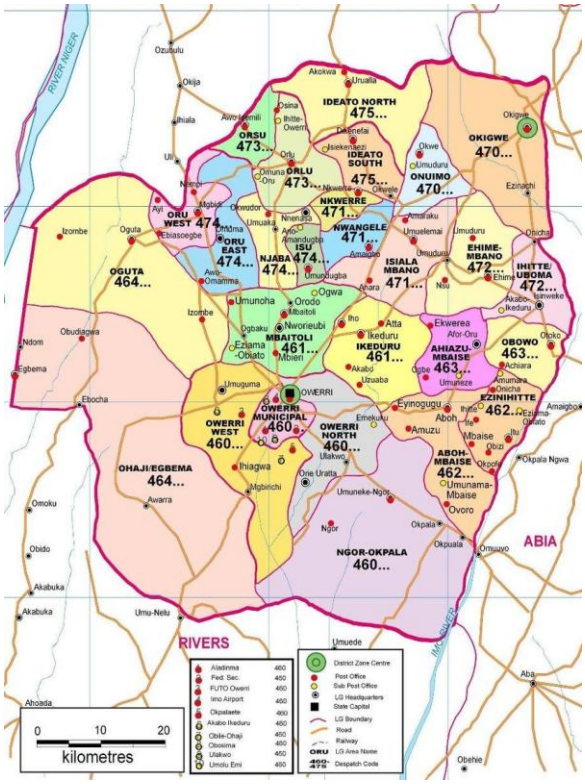
Nevertheless, in order to empirically determine the choice of waste disposal method by the respondents, a study of this nature becomes necessary as there is dearth of information in the study area. The need to access farmers 'choice of adoption of waste disposal in pig production is paramount in order to proffer appropriate policy recommendations aimed at maintaining environs that is devoid of pollutants. Furthermore, the study will equip pig farmers with better technology of waste disposal as against an open lagoon as popularly practiced by farmers which has the potentials of causing air pollution. The study could as well serves as source of research information for scholars who are interested in the subject area. It also provides useful information for agricultural extension agents and environmental protection agency for effective dissemination to the pig farmers. Moreover, the study could serve as a baseline for evaluating efficient pig management practice, at least environmental hazards especially now the climate change effect is a threat to mankind's existence. Equally, it will serve as a reference for further research work in the related area. The specific objectives of the study are to:

i. describe the socio economic characteristics of the respondents;

ii. identify the methods of pig management and waste disposal methods among the pig farmers;

iii. determine the factors affecting the choice of waste disposal methods by pig farmers and

iv. Identify the constraints to wastes in pig production in the study area



MAP OF IMO STATE OF NIGERIA SHOWING OKIGWE LOCAL GOVERNMENT AREA

II. MATERIALS AND METHODS

The study was carried out in Okigwe Local Government Area (LG A) of Imo State, Nigeria. Okigwe LGA comprises of twelve (12) communities (Ezinnachi, Ogii, Umualumoke, Aku, Umuka, Ubaha, Ugwaku, Amuro, Agbobu, Umulolo, Ihube and Umuowa) and many villages. It is located between Longitude$7^{o}44^{1\ of}$ and $7^{o}26^{1}$E Greenwich Meridian and Latitude $5^{o}30^{1}$ and $5^{o}57^{1}$N of Equator. Okigwe Local Government Area covers an area of about 360km^2 with a population of about 132,237 people (NPC 2006). It is bounded in the North by Umuahia South Local Government Area in Abia State, in the East by Onu-imo Local Government Area in Imo State, in the South by Umunneochi Local Government Area of Abia State and in the West by Isuikwuato Local Government Area in Abia State. The area has tropical climate with annual rainfall of about 1800mm-2000mm, mean temperature of about 28^0 -42^0C and relative humidity of 65%. The main seasons experienced in the area are dry season (November-April), and rainy season (May-October). The main crops cultivated in the area are cocoyam, yam and cassava. They also engaged in livestock production, namely: sheep, goat, pig and poultry. The people also engaged in other economic activities such as hunting, tailoring, barbing, petty trading, mechanics, salon and civil services.

Purposive and multi- stage random sampling techniques were used to select communities, farms and respondents. In the first stage, three towns, namely; Agbobu, Umu owa and Umulolo were purposively selected. This is because of the nearest of these towns to NEPROC (palm kernel oil processing company) which serves as source of palm kernel cake for feeding pig. In the second stage, twenty farms were selected from each of the three towns. This brought to a total of sixty pig farms. In the stage three, a pig farmer was selected from each of the farms and a total of sixty farmers selected for detailed study.

Structured questionnaire was used to generate data from pig farmers' personal characteristics, waste management methods and constraints to wastes management in pig production. Furthermore, secondary data was collected through text book, journal paper, conference paper and other periodicals. The objectives i, ii, and iv were captured using percentage responses and frequency distribution table. The objective iii was addressed using Multinomial Logit Model.

III. MODEL SPECIFICATION

3.1 Multinomial Logit Model (MNLM)

This was used to analyze the factors influencing households' choice of adoption of improved pig management practices. According to (Magombo, *et al*; 2011), MNL model for choice of adoption practices specifies the relationship between the probability of choosing an adoption option and the set of explanatory variables. The adoption practices are (adequate pig pen, adherence to 500 meters from pig pen to residential houses, adequate waste storage facilities and proper feed precision management)

The MNL Model is stated as follows:

$$P\left(y = \frac{j}{x}\right) = \frac{\exp(x\beta j)}{[1+\sum jh=1 \exp.(x\beta h), j=1,...,j]} \quad (1)$$

Let x be a 1 x k vector with first element unity.

Where βj is k x1, j=1,...,j

Implicit

$$Y_i = \text{In}(P_i, P_1) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + \beta_9 X_9 + \beta_{10} X_{10} + ei$$

Where;

Y_i= adoption practices (adequate pig pen, adherence to 500 meters from pig pen to residential houses, adequate waste storage facilities and proper feed precision management).

$X_{i,}$ where I = 1,2,….10 are explanatory variables,
X_1 = Sex of the farmers (male =1 and 0 otherwise)
X_2 = Age of the farmers (years)
X_3 = Educational attainment (years)
X_4 = Household size (in number)
X_5 = Rearing experience (years)
X_6 = Flock size (no)
X_7 = Member of farmers organization (yes=1 and 0 otherwise)

X_8 = Extension contact (yes=1 and 0 otherwise)
X_9 = Residential distance to the pig house (km)
X_{10} = Access to credit (yes =1 and 0 otherwise).

IV. RESULTS AND DISCUSSION

The results of the socioeconomic characteristics of the farmers were presented in Table 1

TABLE 1
DISTRIBUTION OF RESPONDENTS ACCORDING TO SOCIOECONOMIC CHARACTERISTICS

Variable	Frequency	Percentage
Gender		
Male	50	83.3
Female	10	16.7
Age		
>20		
21 – 41	20	33.3
42 – 62	35	58.3
63 and above	5	8.4
Educational Level		
No Formal Education	20	33.3
Primary	22	36.7
Secondary	10	16.7
Tertiary	8	13.3
Rearing Experience		
< 5	4	6.7
6 – 10	10	16.7
11 – 15	30	50
Above 16	16	26.6
Extension Services		
Yes	20	33.3
No	40	66.7
Access to Credit		
Yes	50	83.3
No	10	16.7
Membership of Organization		
Yes	35	58.3
No	25	46.7
Household Size		
1 – 3	2	3.3
4 – 6	25	46.7
7 – 10	15	25
10 and above	8	13.3
Flock Size		
>20	12	20
20 – 30	30	50
31 – 40	12	20
41 and above	6	10
Distance from pig house		
1 -200metre	6	10
201 – 400 metres	18	30
< 400 metres	36	60

Source; Field Survey, 2017.

Table 1showed that 83.3% of the pig farmers were males and 16.7% were females. This implies that men are more involved in pig production than women. This finding concurred with (Okollo, 2011) who reported that production is both labour and capital intensive, hence could be best accomplished by men who are endowed to those aforementioned attributes. Also, 58.3% of the pig farmers were within the age brackets of 42-62 and the least fell between 63 years and above. According to (Adesehinwa, 2003) aged people are less able to source and synthesis information on effect of pig production on the environment and not very receptive to adoption of improved pig production technologies. Table 1 reveals that 66.7% of the total respondents were educated, with primary and secondary attainments being the highest, 36.7% respectively. However, only 33.3% of the respondent had no formal education. Education enhances farmers' ability to evaluate, understand, and accept new innovation aimed at checkmating the effect of poor pig management on the environment (Tewe *et al;* 2009)

Beside, 50% of pig farmers had rearing experience of 11 – 15 years, 26,6%; above 16years, 16.7%; 6 – 10 years, while, 6.7%; less than 5 years. The number of years a farmer had spent in the farming business according to (Steinfeld, 2014) could be an indication of the practical knowledge he/she had acquired on how he/she can overcome certain inherent pig management problems that is capable of affecting its environs negatively. This result collaborated with the finding of (Magombo *et al;* 2011) that farming experience enhances efficient use of scarce resources by small holder pig farmers. Moreover, 66.7% of the respondent had no access to extension services and 33.3% had access to extension services. This implies that most farmers had poor access to extension service, hence could likely not to enjoy the services of extension programmes on effect of poor pig production on the environment (John 2011).

Additionally, majority (83.3%) of the respondents had access to credit, while 16.7% had no access to credit. Credit helps farmers to pay for labour and procure inputs to ensure application of appropriate pig production technologies to curtail environmental pollution as result of poor pig management (Powers *et al.,* 2011). Table shows that 58.3% of the respondents were members of farmer' organization, while 46.7% were not. Membership of organization through interaction among members could impact into themselves information as regards to ways of averting the effect of pig production to the environment (Adeschinwa, 2003). As well, 46.7% of the farmers had 4 - 6 household members, 25% had 7 - 10, 13.3% had 10 and above and 3.3% had 1-3. The implication is that farmers that have relatively larger house hold size have more proxy to labour in applying improved technologies on pig production with minimally consequences on the environment (Tewe *et al;* 2009).

More so, majority (50%) of the pig farmers studied had flock size ranging from 20 - 30 pigs, while the least (10%) had flock size ranging from 41 and above. This result confirms to a prior knowledge that farmers in most developing countries are largely small scaled in their farm operation (Tewe *et al;* 2009). Also (Steinfeld 2014) was of the view that farmers' total flock size serves as a good proxy for wealth status and income level. Table 1 shows that majority (60%) of the respondents located their farms between 400m and above to residential houses, 30% located their farms between 201 – 400 m and 10% located their farms between 1 – 200 m. It implies that only 60% of the farmers in the study area met the rules guiding pig farm location as stipulated by the Environmental Protection Agency (EPA) (Okolo, 2011). This implies that neighbours living in that environment could hardly perceive the odour emanating from pig production and management.

The results of pig management and waste disposal methods were presented and discussed in Table 2a.

TABLE 2A
DISTRIBUTION OF RESPONDENTS ACCORDING TO METHODS OF PIG MANAGEMENT

Methods of pig management	Frequency	Percentage
Intensive	50	83.4
Semi Intensive	2	13.3
Extens	2	2.3

Source: Field Survey, 2017

Table 2a shows that 83.4of the respondent used intensive system, 13.3% used semi-intensive system and 2.3% used extensive system. This means that intensive system is more commonly used in pig production and management in the study area. The intensive systems of pig production according to (Powers *et al* 2011) help to checkmate animals' urines and dung which are capable of causing environmental pollutions.

TABLE 2B
DISTRIBUTION OF RESPONDENTS ACCORDING TO WASTE DISPOSAL METHODS

Waste disposal methods	Frequency	Percentage
Open lagoons	50	83.3
Dumping in the farm	38	63.3
Store in Bag	35	58.3
Heap waste and burn	23	38.3
Sales of waste	45	75

Multiple Responses.
Source; Field Survey, 2017

Table 2b shows that 75% of the respondent sale their wastes to farmers who use them as manure. This storage method system helps to reduce the environmental effect of pig production and waste miss management on the environs (Young, 2009;Lee *et al* 2011). The finding of EPA, (2012) was in agreement with the above assertion. They were of the view that pig manure is rich in cupper (Cu), phosphorous (P) and nitrogen (N) (depending on the ingredients the animal was fed) which is very vital for crop production and income source for the farmers when sold. Furthermore, 83.3% of the respondent disposed wastes in open lagoons. This storage method system is often used to hold waste until they can be incorporated into the soil or another means of disposal (Ewuziem *et al;* 2009). The bio- oxygen decomposition (BOD) and nutrient concentration of the wastes collected in lagoons according to (Bradshain *et al* 2004) are reduced by biological activity and chemical reaction. In addition, 63.3% of the respondents dump their waste/ manure in the farm. Animal wastes generally when dumped in the farm as manure could constitute great odour especially if not incorporated into the soil. According to (Getara *et al;* 2009), drag hose and injection could be used to spread manure and as result odour-causing compounds are integrated into the soil in order to curtail maximally the amount of nitrous oxide and ammonia that will be released environment (Okolo, 2011). Also, 58.3% of the total respondents bag their wastes before disposal. (Lee, 2009) were of the view that bagging with the mouth tied will minimize the surface of manure in contact with air, hence reducing environmental air pollution

The factors influencing the choice of waste disposal method by pig farmers using Multinomial Logistic Model were discussed presented in Table 3.

TABLE 3
MULTINOMIAL LOGISTIC REGRESSION ESTIMATES FOR THE CHOICE OF ADOPTATION PRACTICES BY PIG FARMERS IN THE STUDY AREA

Variable	Open lagoon	Dumping in the farm	Store in the bag	Heap waste and burn	Sales of waste
Constant	-56.23198[-0.00]	-11.41238[-2.04]	5.680671[1.44]	6.454008(0.56)	1.003757[1.14]
Gender (Dummy)	125. 6912[0.01]	2.326612 [1.47]	0.5971423[0.59]	10.28021(0.32)	-.150328[1.006]
Age(year)	8.926072[2.00]**	-0.0686951[-0.12]	-8.080355[-1.75]*	- 2.89090[0.54]	-4.150320[1.06]*
Education(Years)	-14.68885[0.16]	0.147936 (0.25)	0.4851057(0.92)	0.342456[1.62]	4.118757[1.04]
H. hold size(No.)	-71.590454[-0.01]	1.03511[1.25]	-0.6294666[-0.94]	-2.80003[2.002]	1.154058[1.36]*
Experience(Years)	42.27053[0.00]	3.59616[0.84]	1.472007[1.38]*	2.338909(3.00)***	13.336368[1.72]**
Number of pigs[No.]	-30.3213[-0.01]	1.113757[1.34]*	-1.352448[-2.04]**	-6.009076[0.13]	3.560328[1.66]
Farmers organization [Dummy]	-65.33479[-1.001]*	2.150328[0.86]	1.868094[2.79]**	8.0087664[0.76]	0.7654000[.1.00*]
Extension services	-33.0861601[-0.01]	0.229368[0.22]	0.1677062[0.19]	3.7650000[0.06]	1.439390[0.22]
Distance residence	-11.4785[-0.00]	-1.375358[-1.47]	-2.410415[-0.3.01]***	15.006753[0.00]	-3.675900[0.09]
Log likelihood = -48.266540 Pseudo R2 = 0.4821 LR chi2(60) = 78.08					
Base outcome = adequate waste storage facilities. ***, ** and* shows significant at 1%, 5% and 10% levels of probability respectively. Figures in bracket represent z-values.					

Source; Field Survey; 2017

The result of multinomial logistic model showed the factors influencing the choice of adoption practices by pig farmers in the study area. Table 3 showed that the factors influencing the choice of use of practices options inserted into multinomial logistic model were open lagoon, dumping in the farm, store in the bag, heap waste and burn and sales of waste. The likelihood ratio statistics are indicated by statistics R^2 (-48.26) and was highly significant, suggesting the model has a strong explanatory power.

The coefficient of age of the household was positive and had significant impact on the choice of waste disposal methods/ technologies by pig farmers in order to curtail minimally environmental pollution. This implies that as the farmers get aging, the probability of adopting waste disposal method in pig production using sales of wastes, store in bags and store in open lagoon. This could be because old age is often associated with long years of farming experience and could positively influence adoption decision process (Lee, 2009). In contrary, (Ajala, *et al* 2007) found negative relationship between farmers age and adoption of technology. He reported that as farmers become older, they are less energetic and risk averse to technology adoption. Coefficient of the farming experience of the sampled household head had a positive and significant effect on the use of store in the bag, heap wastes and burn and sales of wastes in overcoming effect of pig wastes to the environs. Experienced farmers are always capable of using techniques as result of long years in the enterprise in overcoming possibly mismanagement practices in pig production which could result in air pollution (Adesehinwa, 2003). Although, experience in farming is very important and depends on years of farming experience, yet averagely young farmers are needed in business since pig production and management of waste is energy snapping. This statement agreed with Wright and Bossard (2011) and John (2011). They opined opined that apart from pig production being labour intensive, the improved technologies of pig production and management of animal waste that aimed at safe guiding environmental pollution are relatively scarce. The coefficient of number of pigs (Flock size) had a negative and significant effect on choice of using dumping wastes in the farm and heap and burn as a waste disposal method or technology in wastes management in pig production. The larger the flock size, the higher the amount of waste the farmer is left to manage or dispose. Nevertheless, (Ewuziem 2008) reported that flock size played an important role in farm success because it reflects the availability of capital, access to credit and even good management ability. In most developing countries, pig production is largely small scaled in operation and this could be linked to poverty as pig rearing is highly capital intensive (Tewe *et al* 2009) coefficient of farmers' membership of organization was positive and had significant effect in adapting of waste disposal technologies through sales of wastes, store in a bag and well managed open lagoon in order to minimize air pollution often associated with poor pig management. Farmers' organization helps to educate and train members on safe method of pig management and the consequences of the abuse. The coefficient of the distance of the pig pen to residential houses had a negative and significant effect on choice of waste disposal method on practices. This implied that neighbours living in that environment could hardly perceive the odour emanating from pig production and waste management, no matter they are living to pig house. This assertion did not concur with (Gekara et al 2009) who opined that the minimum distance to live near pig farms without perceiving the odour is 500metres.

The constraints to waste management in pig production are presented in Table 4.

TABLE 4
CONSTRAINTS TO WASTE MANAGEMENT IN PIG PRODUCTION IN THE STUDY AREA.

Constraint	Frequency	Percentage
Poor access to credit	56	93.3
Poor road network	38	63.3
Veterinary posts	45	75
Water problem	38	63.3
Housing	35	58.3
Poor access to exten. Services	52	86.7
High cost of Labour	35	58.3
Feed and Feeding	26	43.3
Water	24	40

Multiple Responses
Source: Field Survey, 2017

Table 4 showed that poor access to credit constituted the greatest hindrance to waste management in pig production in the study area and accounted for 93.3% of the total respondents. Iheke (2010) reported that credit facilities adoption of innovations in efficient waste management and payment of labour in implementing the technologies. As well, 86.7% of the respondents reported the problem of poor extension services as barrier to wastes management in pig production. Extension services are needed to disseminate information as well as technical assist to farmers on how best to curb environmental challenges associated with wastes mismanagements (Asiabaka, 2003;Adeschinwa 2003; Sudahmed 2008).

Also, 75% of the sampled farmers encountered the problem of veterinary posts being cited in urban areas. Most veterinary posts are urban based in the study area and access to their services on information regarding precision feed management to reduce animal wastes and drugs to reduce nitrogen (N) and hydrogen sulphide(H_2S) contents of animal wastes which constitute significantly the odour observed in animals' wastes is often limited (Bradshain *et al* 2004) . Moreover, 63.3% of the sampled pig farmers were faced with the problem of poor road network. The deplorable conditions of our roads especially in our rural and farm road are of great concern and very pathetic. The roads in many of the areas are impassable especially during rainy season, thus constitutes a clog in wheel of disposing pig wastes to farmers' farms in the neighbouring vicinity for usage. Consequently, such indisposed waste(s) could constitutes source of odour as many pig farms' have accommodation problem and poor technologies to adequately conserve such wastes to avoid polluting the environments (Rogers 2003; Ume *et al;* 2013). The other problems of wastes management in pig poultry were water problem (63.3%), problem of housing (58.3%) and high cost of labour(58.3%)

V. CONCLUSION AND RECOMMENDATION

Based on the results, the following conclusions were made;

Most of the respondents were aged, educated, had large household size and member of organizations. In addition, on the method of pig management, intensive method was the most popular. Furthermore, open lagoon, dumping in the farm and store in the bag were the major methods for waste disposal in pig production in te study area. Also, the multinomial logistic model results showed that age of the respondents, membership of organization and farming experience were positive to the choice of adaptation practices by pig farmers in the study area.

Finally, the major constraints to wastes managements to pig production were poor access to credit, poor road network and location of veterinary post, high labour costs, and poor housing problems and poor road net work.

Based on the findings, the following recommendations were made;

1) Extension services in the country should be boosted through employing more extension agents in order to reduce extension – farmers' ratio for effective communication to be ensued. In addition, the change agents should be adequately motivated through prompt payments of salaries and other incentives.

2) Price of building materials (such as cement, timber, zinc, and others) should be subsidized by government to enhance farmers' easy access. This will help to ensure that pig farmers use intensive pig management practice for easer control of air pollution often associated with mismanagement of pig production as against extensive management type.

3) There is need to encourage pig farmers to sink bore holes or locate their farms close to streams to have access to water for both animal consumption and cleaning of pig pens and its accessories.

4) The veterinary personnel should be encouraged to established veterinary posts in rural areas in order that pig farmers will avail to the opportunity to tackle their waste management problem as the needs arise.

5) Farmers' access to credit through microfinance banks, commercial banks and other credit facilities should be ensured.

6) The environmental laws which stipulated that pig houses should be suited 500 meters away to residential buildings should be seriously implemented by the appropriate government agencies in order to minimize the effects of pig mismanagement to the neighboring residents.

7) Pig wastes should be managed and disposed off in accordance to rules and regulations to avoid hazardous situation and achieve environmental balance and safety.

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Use of Triple Bagging Systems and Lippia Multilora Leaves for the Protein-Energy Quality Preservation of Cowpea Seeds (*Vigna unguiculata L. Walp*).

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Abstract— *Cowpea is a food legume highly appreciated in the traditional diet of the populations in Ivory Coast. It is confronted with storage and / or preservation problems which prevent his production in large quantity. This experiment carried out in Ivory Coast, made it possible to evaluate the effectiveness of the triple bagging systems combined or not with the use of Lippia multiflora leaves on maintaining the cowpea seeds protein-energy quality during preservation. Thus, a 6x6 factorial design was considered to evaluate the cowpea seeds protein-energy quality. The first factor consisted to six types of packaging namely: one control with polypropylene bag (TST), one triple bagging batch (composed of 2 internal layers in independent high density polyethylene 80 mm thick and a woven bag polypropylene) without biopesticide (H0), and four batches (H1, H2, H3 and H4) containing respectively (0.7%; 2.5; 4.3%; and 5%) biopesticide. And second factor storage time, it included six periods of observation (0; 1; 2; 4.5; 7 and 8 months). Results showed significant influence of the interaction between types of treatments and storage time upon protein-energy quality of cowpea. Indeed, the polypropylene control was destocked at 4.5 months and very significant changes were recorded in the protein-energy quality of the cowpea seeds. Also, in the triple bagging systems without biopesticide significant changes were observed to seven months of storage in the contents of moisture (10.03% to 12.55%); ash (2.73% to 2.40%); fiber (5.15% to 4.37%); lipids (1.86% to 1.40%); proteins (22.75% to 15.21%); starch (53.80% to 42.27%); total carbohydrates (62.62% to 68.44%); total sugars (15.89% to 8.15%); reducing sugars (3.12% to 2.20%) and energy value (358% to 347.20%). However, cowpea seeds stored in triple bagging systems with biopesticide retain protein energy characteristic better for eight months period. The average values of analysis tests remained around: 12.06% humidity; 2.60% ash; 4.98% fiber; 18.50% proteins; 1.73% lipids; 52.13% starch; 65.13% total carbohydrates; 14.10% total sugars; 3.00% reducing sugars and finally 350.05% energy value. The results of the multivariate analysis indicate that the 0.7% biopesticide concentration is effective and maintains the protein-energy quality of the cowpea seeds for up to 8 months.*

Keywords— Cowpea, preservation, triples bagging, biopesticide, protein energy characteristics.

I. INTRODUCTION

For more than 3500 years, cowpea (*Vigna unguiculata* L. Walp) has been one of most important legumes in nutrition of the peoples of African, Asian and Mediterranean continents (Bliss, 1972). Today, with an annual world production of 6.4 million tons (Nteranya and David, 2015), this food legume, consumed in various forms (donuts, boiled, mash, dough and sauce) is very popular throughout Africa because seeds are a valuable source of protein, less expensive for most populations. Indeed, cowpea seeds contain essential amino acids (Smart, 1964; Hignard, 1998; Archana and Jawali, 2007). Moreover, they provide a quantity of 3400 calories (Mukendi *et al*., 2014). Cowpea seeds are also an important source of carbohydrates, in particular dietary fiber (Bliss, 1972). Thus, the relatively balanced nutritional characteristics of cowpea seeds make it a very useful supplement in the diet. They are able to solve the problems of malnutrition and more specifically protein-energy deficiencies in sub-Saharan Africa. Furthermore, they are rich in micronutrients (essential minerals and vitamins) essential for the proper functioning of the body.

However, despite its importance, cowpea is faced with storage and / or conservation problems mainly due to attacks caused by pests such as bruchids (Agyen-Sampong, 1978; Doumma *et al*., 2011). This situation is supported by the lack of mastery of good post-harvest practices. In addition, inadequate storage makes the seeds vulnerable to microorganisms (fungi and storage bacteria) which qualitatively and quantitatively deteriorate stored grains (Bhushan *et al*., 2016; Konan, 2017). These microorganisms negatively affect protein energy quality (protein levels, starch, fatty acids, reducing sugars, non-reducing sugars and energy value) of the stored grains.

In order to cope with these stock destroyers, producers often resort to synthetic pesticides whose bad practices (misuse, lack of precaution in their handling and failure to meet the waiting periods for deficiency) can lead to the resistance of pests and diseases to environmental and health problems (Kétoh, 1998).

Given the extent of the damage caused by the use of these chemicals, the use of biopesticide as an alternative has been encouraged in recent decades (Bambara *et al*., 2008; Gueye *et al*., 2011; Kayombo *et al*., 2014).

Indeed, use of plants and their derivatives to treat and protect food is a very old practice in rural areas. It is an effective means of control, guarantees biodiversity and is less expensive (Regnault-Roger, 2002; Ketoh *et al*., 2005; Isman, 2006; Gueye *et al*., 2011). Among the aromatic plants used, is *Lippia multiflora*. It is a local plant and accessible in every region of Ivory Coast whose insecticidal and / or insect repellent properties have been revealed by recent cowpea preservation works (Illiassa, 2004; Tatsadjieu *et al*., 2009; Ilboudo *et al*., 2010; Konan, 2017).

Triple bagging systems are also frequently used in the preservation of cereals and legumes, including cowpea. They consist of a double layer of high density independent polyethylene placed inside a polypropylene woven bag. These systems have shown their effectiveness to extend the shelf life of cowpea seeds (Moussa *et al*., 2009; Baoua *et al*., 2012; De Groote *et al*., 2013; Vales *et al*., 2014; Mutambuki *et al*., 2015; Mutungi *et al*., 2016).

However, there are no recorded scientific data on evolution of protein-energy characteristics of cowpea seeds preserved in triple bagging systems to our knowledge in Ivory Coast. Thus, the purpose of the present working is to evaluate effects of triple bagging systems combined or not with use of *Lippia multiflora* leaves (biopesticide) on evolution of the biochemical characteristics (protein-energy quality) of cowpea seeds during the preservation.

II. MATERIAL AND METHOD

2.1 Experimental site

The experiment was carried out at the Laboratory of Biochemistry and Food Sciences (LaBSA) of the UFR Biosciences at the University Felix HOUPHOUET-BOIGNY. The different bags were stored in a laboratory storage room at 28.0 ± 0.2ºC of temperature and 75.0 ± 1.0% relative humidity. Wooden pallets have been placed on the floor as a support for the various types of packaging bags.

2.2 Biological material

Cowpea seeds used belong to the local variety "Vya". They were collected from producers in the Loh-Djiboua region (5° 50′ North 5° 22′ West) from April to May 2015 just after harvest. After hulling, the seeds have not undergone any treatment were sent to the laboratory for their packaging.

The leaves of *Lippia multiflora* were collected in Gbeke region in May 2015. They were dried out of the sun and then chopped in fine particles.

2.3 Storage equipment

Storage bags used were constituted polypropylene bags and triple bagging systems. The triple bagging systems obtained from the suppliers were composed of two internal layers of polyethylene liners (composed of 80 mm high density) and a third layer made from woven polypropylene. The two layers polyethylenes, one adapted inside the other, were enclosed in the polypropylene woven bag.

2.4 Protocol of cowpea seeds preserving

The experimentation was carried out from June 2015 to February 2016. It was implemented using the methodology of preservation by bagging cowpea seeds suggested by Konan *et al*., (2016) modified.

These authors using a central composite design with five levels represented by two factors (shelf life 1 to 8 months and proportion of biopesticide 0 to 5%) followed the evolution of merchantability and health quality during the storage in triple bagging systems. Thus, in our study one control batch and five experimental batches were constituted. The control group consisted of cowpea seeds put in polypropylene bags (TST). For the five experimental batches, they included one lot containing cowpea seeds in triple bagging systems without biopesticide (H0) and four batches of cowpea seeds packed in triple bagging systems with different concentrations (H1: 0.7%); H2: 2.5%; H3: 4.3% and H4: 5%) chopped dried leaves of *Lippia multiflora*. The filling of the bags was made by alternating cowpea seeds and leaves as stratum. The mass of each bag was 50 kg.

2.5 Sampling

Sampling for analysis was carried out at different storage periods (Konan *et al*., 2016). The first analysis was done just before the conditioning for conservation (0 months). The aim was to determine base values (references) and then compare them to values obtained during preservation. Then cowpea samples (2.5 kg) were taken in triplicate at 1; 2; 4.5; 7 and 8 months. Bag sampling was done randomly. The samples were then milled in a hammer mill in the laboratory to obtain a fine grind to determine the biochemical parameters (protein-energy quality).

2.6 Biochemical analysis of samples

Proximate analyses were carried out using standard methods AOAC (2000) to determine biochemical changes. Thus, moisture, ash, fiber, lipid, protein, total sugars, reducing sugars, total carbohydrates, starch and energy values were determined. All analyzes were performed in triplicate.

Thus, cowpea moisture was deduced after drying 10 g of the samples in an oven (MEMMERT, Germany) at 105°C until a constant weight was obtained.

The ash content resulted from incineration of 5 g of the cowpea dried sample at 550 ° C in an oven (PYROLABO, France) for 12 h until a light gray ash occurred.

For crude fibers, 2 g of crushed cowpea samples were taken. Then, extraction mixture was prepared using 0.25 M sulfuric acid and 0.31 M sodium hydroxide with intermittent boiling. After suction filtration, the insoluble residue was washed with hot water, dried with an oven (MEMMERT, Germany) at 100°C for 2 h then incinerated. The final residue allowed estimation of the crude fibers content.

The proteins contents were determined with use of the Kjeldhal method.

The lipids contents resulted from a solvent (hexane) extraction using a Soxhlet device.

Starches contents were determined using iodine method of Jarvis and Walker (1993).

Total soluble sugars amounts were determined by the method of Dubois *et al*. (1956) with phenol and sulfuric acid, then reducing sugars were measured out according to the method of Bernfeld *et al*. (1955) basing on the 3, 5-dinitrosallicylic acid reagent. Prior to their quantification; sugars were extracting with ethanol, zinc acetate and oxalic acid (Agbo *et al.*, 1985). Total carbohydrate and energy value were estimated using the following formulas (FAO, 2002):

Carbohydrates (%) = 100 - (% moisture + % proteins + % lipids + % ash).

Energy (%) = (% proteins X 4) + (% carbohydrates X 4) + (% lipids X 9).

The results of proteins, lipids, ash, fiber, starch, total carbohydrates content, total soluble and reducing sugars were expressed on the dry weight basis.

2.7 Statistical analysis

The statistical analyzes of data were carried out thanks to software SPSS (version 22.0) and STATISTICA (version 7.1). All assays for biochemical characteristics were performed in triplicate and the results are expressed as mean ± standard deviation. A repeated measure ANOVA (ANOVA mixed) was first performed on all the results during the first four and a half months of conservation. It consisted in Analysis of Variance according to two factors: duration and type of treatments and then completed by a one-way Analysis of Variance (ANOVA 1) for the rest of conservation period (7 and 8 months). The purpose of these tests was to determine the existence of significant statistical differences between the calculated mean values. The significant statistical differences were highlighted by the Tukey test at 5% significance level. Finally Correlations between parameters were also assessed according to the Pearson index. Then, Multivariate Statistical Analysis (MSA) namely Principal Components Analysis (PCA) and Ascending Hierarchical Classification analysis (AHC) were performed.

III. RESULTS

3.1 Evolution of the nutritive parameters (protein energy quality) of cowpea seeds according to treatments during preservation

The statistical traits used to evaluate all biochemical parameters during storage are indicated in Tables (I, II and III). These tests reveal significantly changes (P <0.05) in the content of these parameters assessed according to the duration and type of treatments; whether or not the cowpea seeds were stored using the triple bagging method and whether they were treated or not treated with the biopesticide.

3.1.1 Moisture content

Tables IV and V show the moisture of cowpea seeds stored according to treatments. With mean of 10.03 % at the beginning (0 month), the moisture contents increases significantly (P <0.001) during the storage period. The highest moisture values were recorded after 4.5 months of storage in the control polypropylene bag with a mean of 14.67%. In the triple bagging system without biopesticide, from the 7th month of storage, this rate increased rapidly (12.55%) to 8 months of storage, the value of 14.10% (Table V). While in triple bagging systems with different proportions of biopesticide, the moisture content of cowpea seeds remained around 12.06% during the 8 months of storage (Table V). Furthermore, the interaction between the type of treatments and storage periods has a significant effect (P <0.001) upon this parameter (Table II).

3.1.2 Ash, fibers, protein and lipid contents

In triple bagging systems with different proportions of biopesticide, ash content remained constant during the 8 months of storage with a mean of 2.60% (Table V). The values of the ash content in the triple bagging system without biopesticide (H0) decrease significantly (P <0.001) after 2 months of storage (Table IV) to reach a value of 2.40% in month 7 (Table V). As for the control polypropylene bag (TST) the change is significant during the 4.5 months of storage thus increasing from 2.73% to 1.80%.

On the other hand, the lipids contents do not change significantly with the storage periods for triple bagging systems containing biopesticide (Table IV and V). Similar comments have been made for fiber and protein contents in these storage systems (Table IV and V). It is at the end of the 8th month of storage, the decrease for protein content becomes appreciable in the different triple bagging systems containing biopesticide, whereas the change for the fiber contents become significant (P <0.001) in the triple bagging with 0.7% biopesticide. However, in both types of bags without biopesticide, these macronutrients (fiber, lipids and proteins) change significantly (P <0.001) with the duration, type of treatments and the interaction between these two variables with a strong emphasis for the control (TST). Indeed, with a mean value of 22.75% at the beginning of storage (0 month), the protein content of cowpea seeds drops to 11.23% in the polypropylene bag (control) after 4.5 months (destocking period) and 15.21% in the triple bagging system without biopesticide after 7 months of storage. Similarly, in the control bag (TST) and the triple bagging without biopesticide (H0) the fiber and lipid contents decreased significantly (P <0.001) from 5.15% of fibers at the beginning to 4.07% at the end of 4.5 months of storage for control TST and to 4.37% and 3.73% respectively after 7 and 8 months of storage for H0. Regarding lipids, the rates of 1.86% at the beginning drop to 1.07% at 4.5 months for the control polypropylene and to 1.40% and 1.18% at 7 and 8 months for H0 bags.

3.1.3 Starch and total carbohydrates contents

The starches contents are significantly influenced (P <0.001) by the duration and type of treatments, also by the interaction between the two variables (Tables I and II).

A gradual decrease is observed with storage periods for two types of bags without biopesticide (TST and H0). The starches contents of cowpea seeds at the earlier storage 53.80% drop to 40.43% in the polypropylene control (TST) during the 4.5 months of storage (Table VI). In the triple bagging system without biopesticide (H0) this rate drops to 42.27% after 7 months of storage and 41.65% after 8 months of storage. For the other types of treatment (triple bagging with different proportions of biopesticide), no significant difference was revealed during the entire storage period (Table VI and VII).

For total carbohydrates, a significant change (P <0.001) in all samples was observed with an increasing trend. This rise is more pronounced in the samples (TST and H0). These rates vary respectively from 62.62% to 71.23% (TST) after 4.5 months of storage (Table VI) and from 62.62% to 68.44% (H0) after 7 months of storage. In the various triple bagging systems with biopesticide, the mean fluctuate between 64.61% and 65.13% after 8 months of storage (Table VII).

3.1.4 Total and reducing sugars

The post harvest cowpea storage revealed a significant decrease (P <0.001) in the total sugars contents during storage. This decrease is more marked in the control group and the triple bagging system without biopesticide (Tables VI and VII). During the 4.5 months of the polypropylene control storage, a drop from 15.89% at the beginning of storage to 6.99% in the month

of destocking (month 4.5) was recorded. Similarly, in the triple bagging system without biopesticide, a drop of 15.89% to 8.15% and 6.70% was observed respectively after 7 and 8 months of storage. Total sugars contents for triple bagging with 0.7% biopesticide (H1) decreased significantly from 15.89% (month 0) to 11.90% after 8 months of storage. For cowpea seeds treated with 2.5%; 4.3% and 5% of biopesticide no significant change was observed after 8 months of storage (Tables VII). Regarding reducing sugars, there is a significant difference ($P < 0.001$) between the beginning and end of storage for the TST control and the H0 bag. The means change respectively from 3.12% to 1.51% after 4.5 months of storage and from 3.12% to 2.08% at 8 months of storage. For triple bagging systems with biopesticide there was no significant change between the types of treatments after 8 months of storage (Table VII).

3.1.5 Energy values

The energy values estimated at 358.25 kcal / 100g before storage. dropped significantly ($P < 0.001$) after 4.5 months of storage (353.91 kcal / 100g) both in triple bagging systems with biopesticide and in the triple bagging system without biopesticide (Tables VI). However, after 8 months of storage this value reaches 340.70 kcal / 100g in the bag (H0) and remains around 350.05 kcal / 100g in the systems (H1, H2, H3 and H4) (Table VII).

For the TST control the significant decrease ($P < 0.001$) was observed over the entire storage period (4.5 months) and the values at the end of storage were 339.47 kcal / 100g.

3.2 Correlations between nutritive parameters

The Pearson index (r) indicate positive and negative significant correlations between the 10 parameters assessed for cowpea samples untreated and from different treatments (Table VIII). Thus, ash, fibers, proteins, lipids, total sugars, reducing sugars, starch and energy value are closely correlated during storage of cowpea, with r varying from 0.80 to 0.98. Indeed, the contents of proteins and reducing sugars change tightly ($r = 0.90$). The starch contents are directly correlated with the fiber contents ($r = 0.92$). Positive significant correlations are observed between lipid contents and reducing sugars ($r = 0.96$). The ash content during storage is proportional to that of the reducing sugars ($r = 0.96$). The energy value is strongly influenced by protein and lipid contents. Conversely, changes in total carbohydrate contents are negatively correlated with protein, starch, fiber, lipid, reducing and total sugars, ash and energy content. In addition, the analysis also showed that an increase in the moisture content strongly coincides with a decrease of the 8 other biochemical parameters studied.

3.3 Variability between types of treatments and nutritive parameters during storage

Principal Component Analysis (PCA) was achieved with the main factors F1 and F2 (Table IX) delivering eigenvalue equal or superior to 1, according to statistical standard of Kaïser. Then, gatherings highlighted from the PCA were clarified by Ascending Hierarchical Classification (AHC) performed with the Unweighted Pair Group Method with Arithmetic means (UPGMA).

3.4 Multivariate analysis

Principal component analysis (PCA) correlated whole characters studied with two factors "Fig. 1.a". However, only the first factor (F1) with an eigenvalue greater than 1 and cumulating 90.23% of the total variability of all parameters was considered for the PCA data interpretation. Thus the F1 factor of eigenvalue 9.02 is significantly positive correlated with moisture and total carbohydrate contents, but negatively with the protein, starch, fiber, ash, lipid, total sugars and reducing sugars, and the energy value. However, the factor F2 of eigenvalue 0.49 and of total variability 4.90 is associated with F1 for the PCA representation. The projection of the samples studied highlighted 3 groups of individuals "Fig. 1.b". Indeed the samples from the first group have high moisture and total carbohydrates contents. Those in the second group recorded more significant levels of proteins, lipids, ashes, fibers, total and reducing sugars, starch and energy value. On the other hand, the samples of the third group are not specifically distinct from those of second group. However the Ascending hierarchical classification (AHC) shows a large class comprising individuals from both the second and third PCA groups "Fig. 2". This shows that all individuals of the samples preserved with biopesticide respectively at 7 and 8 months (C4 to F5) are close to the second group, which are in fact the initial sample, just after harvest (EI), samples from 1 month of preservation (A1 to F1), also with the exception of the polypropylene control, those with 2 months of preservation (B2 to F2) and finally individuals from samples preserved with biopesticide at 4.5 months (C3 at F3).

When the individuals in the first group, they consist of control samples polypropylene at 2 months (A2), polypropylene and triple bagging without biopesticide at 4.5 months (A3-B3) and triple bagging without biopesticide at 7 and 8 months (B4 and B5).

TABLE 1
STATISTICAL DATA (MIXED ANOVA) OF PROTEIN-ENERGY CHARACTERISTICS OF COWPEA SEEDS UNDER TREATMENT DURING PRESERVATION

SOV	Stat. Para		PRC	LPC	STC	FBC	TSC	RSC	ASC	TCC	EC	MC
Durations	Sphericity hypothesis	df	3	3	3	3	3	3	3	3	3	3
		SS	63.434	0.550	165.801	0.602	68.868	1.593	0.580	59.380	522.298	30.417
		MS	21.145	0.183	55.267	0.201	22.956	0.531	0.193	19.793	174.099	10.139
		F	41.671	50.689	86.169	46.915	234.226	97.788	44.271	55.948	225.741	812.877
		P	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**
	Greenhouse-Geisser	df	2.525	1.806	2.807	2.490	2.371	2.180	2.200	2.743	1.939	1.433
		SS	63.434	0.550	165.801	0.602	68.868	1.593	0.580	59.380	522.298	30.417
		MS	25.120	0.305	59.066	0.242	29.047	0.731	0.264	21.646	269.386	21.220
		F	41.671	50.689	86.169	46.915	234.226	97.788	44.271	55.948	225.741	812.877
		P	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**
Error	Sphericity hypothesis	df	36	36	36	36	36	36	36	36	36	36
		SS	18.267	0.130	23.090	0.154	3.528	0.195	0.157	12.736	27.764	0.449
		MS	0.507	0.004	0.641	0.004	0.098	0.005	0.004	0.354	0.771	0.012
	Greenhouse-Geisser	df	30.302	21.667	33.684	29.874	28.451	26.158	26.403	32.918	23.266	17.202
		SS	18.267	0.130	23.090	0.154	3.528	0.195	0.157	12.736	27.764	0.449
		MS	0.603	0.006	0.685	0.005	0.124	0.007	0.006	0.387	1.193	0.026

***SOV**: source of variation ; **Stat Para**: statistical parameters ; **df**: degree of freedom ; **SS**: sum of squares ; **MS**: mean squares ; **F**: value of the statistical test ; **P**: probability value of the statistical test ; **PRC**: protein contents ; **LPC**: lipid content ; **STC**: starch content ; **ASC**: ash content ; **FBC**: fiber content ; **TSC**: total soluble sugar content ; **RSC**: reducing sugar content ; **TCC**: total carbohydrate content ; **EC**: energy content ; **MC**: moisture content.*

TABLE 2

STATISTICAL DATA (MIXED ANOVA) OF PROTEIN-ENERGY CHARACTERISTICS OF COWPEA SEEDS UNDER TREATMENT DURING PRESERVATION

SOV	Stat. Para		PRC	LPC	STC	FBC	TSC	RSC	ASC	TCC	EC	MC
Treatments		**df**	5	5	5	5	5	5	5	5	5	5
		SS	219.834	1.249	320.503	1.880	143.376	4.911	1.663	130.568	376.229	22.597
		MS	43.967	0.250	64.101	0.376	28.675	0.983	0.333	26.114	75.246	4.519
		F	134.958	96.510	86.919	77.175	140.116	133.687	86.558	96.299	75.302	292.153
		P	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**
Error		**df**	12	12	12	12	12	12	12	12	12	12
		SS	3.909	0.031	8.850	0.058	2.456	0.088	0.046	3.254	11.991	0.186
		MS	0.326	0.003	0.737	0.005	0.205	0.007	0.004	0.271	0.999	0.015
Durations x treatments	**Sphericity hypothesis**	**df**	15	15	15	15	15	15	15	15	15	15
		SS	230.064	0.640	291.212	1.587	127.105	4.127	1.115	119.405	338.509	22.474
		MS	15.338	0.043	19.414	0.106	8.474	0.275	0.074	7.960	22.567	1.498
		F	30.227	11.795	30.269	24.724	86.459	50.677	17.028	22.501	29.261	120.121
		P	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**
	Greenhouse-Geisser	**df**	12.626	9.028	14.035	12.448	11.855	10.899	11.001	13.716	9.694	7.167
		SS	230.064	0.640	291.212	1.587	127.105	4.127	1.115	119.405	338.509	22.474
		MS	18.221	0.071	20.749	0.128	10.722	0.379	0.101	8.706	34.919	3.136
		F	30.227	11.795	30.269	24.724	86.459	50.677	17.028	22.501	29.261	120.121
		P	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**

***SOV**: source of variation ; **Stat Para**: statistical parameters ; **df**: degree of freedom ; **SS**: sum of squares ; **MS**: mean squares ; **F**: value of the statistical test ; **P**: probability value of the statistical test ; **PRC**: protein contents ; **LPC**: lipid content ; **STC**: starch content ; **ASC**: ash content ; **FBC**: fiber content ; **TSC**: total soluble sugar content ; **RSC**: reducing sugar content ; **TCC**: total carbohydrate content ; **EC**: energy content ; **MC**: moisture content.*

TABLE 3

STATISTICAL DATA (ANOVA 1) OF PROTEIN-ENERGY CHARACTERISTICS OF COWPEA SEEDS UNDER TREATMENT DURING PRESERVATION

Effect	Stat para	PRC	LPC	STC	FBC	TSC	RSC	ASC	TCC	EC	MC
Treatments	**df**	4	4	4	4	4	4	4	4	4	4
	SS	63.081	0.744	297.700	4.157	151.065	2.161	0.389	39.340	224.000	10.592
	F	8.940	22.242	78.500	109.560	120.769	39.048	16.060	5.630	149.000	219.60
	P	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.05**	**<0.001**	**<0.001**
Error	**df**	10	10	10	10	10	10	10	10	10	10
	SS	17.641	0.084	9.480	0.095	3.127	0.138	0.060	17.480	4.000	0.121
Total	**df**	14	14	14	14	14	14	14	14	14	14
	SS	80.722	0.828	307.18	4.252	154.192	2.299	0.449	56.820	228.000	10.713

***Stat Para**: statistical parameters ; **PRC**: protein contents ; **LPC**: lipid content ; **STC**: starch content ; **ASC**: ash content ; **FBC**: fiber content ; **TSC**: total soluble sugar content ; **RSC**: reducing sugar content ; **TCC**: total carbohydrate content ; **EC**: energy content ; **MC**: moisture content.*

TABLE 4
EVOLUTION IN PROTEIN ENERGY CHARACTERISTIC (MOISTURE, ASH, LIPID, PROTEIN AND FIBER) ACCORDING TO TREATMENT AT 4.5 MONTH OF STORAGE (ON DRY WEIGHT BASIS)

Parameters	Storage time (month)	TST	H0	H1	H2	H3	H4
Moisture (%)	0	10.03±0.21^{aA}	10.03±0.21^{aA}	10.03±0.21^{aA}	10.03±0.21^{aA}	10.03±0.21^{aA}	10.03±0.21^{aA}
	1	10.24±0.06^{aA}	10.09±0.02^{aA}	10.07±0.03^{aA}	10.03±0.06^{aA}	10.03±0.02^{aA}	10.03±0.06^{aA}
	2	12.30±0.10^{bB}	10.22±0.02^{aA}	10.10±0.05^{aA}	10.08±0.02^{aA}	10.08±0.02^{aA}	10.07±0.04^{aA}
	4.5	14.67±0.15^{cB}	11.17±0.06^{bA}	11.05±0.06^{bA}	11.01±0.03^{bA}	10.99±0.01^{bA}	10.99±0.01^{bA}
Ash (%)	0	2.73±0.06^{aA}	2.73±0.06^{aA}	2.73±0.06^{aA}	2.73±0.06^{aA}	2.73±0.06^{aA}	2.73±0.06^{aA}
	1	2.51±0.03^{aB}	2.57±0.03^{aB}	2.68±0.18^{aA}	2.70±0.12^{aA}	2.71±0.02^{aA}	2.71±0.03^{aA}
	2	2.10±0.10^{bC}	2.53±0.06^{bB}	2.66±0.05^{aA}	2.69±0.05^{aA}	2.70±0.02^{aA}	2.71±0.04^{aA}
	4.5	1.80±0.10^{cC}	2.48±0.03^{bB}	2.63±0.04^{aA}	2.67±0.02^{aA}	2.68±0.02^{aA}	2.69±0.01^{aA}
Lipid (%)	0	1.86±0.05^{aA}	1.86±0.05^{aA}	1.86±0.05^{aA}	1.86±0.05^{aA}	1.86±0.05^{aA}	1.86±0.05^{aA}
	1	1.53±0.06^{bB}	1.80±0.00^{aB}	1.82±0.03^{aAB}	1.83±0.06^{aA}	1.83±0.04^{aA}	1.84±0.03^{aA}
	2	1.38±0.03^{cC}	1.72±0.03^{bB}	1.80±0.02^{aAB}	1.80±0.01^{aA}	1.83±0.04^{aA}	1.83±0.05^{aA}
	4.5	1.07±0.12^{cD}	1.57±0.15^{bC}	1.73±0.03^{aB}	1.77±0.10^{aA}	1.79±0.01^{aA}	1.80±0.02^{aA}
Protein (%)	0	22.75±0.87^{aA}	22.75±0.87^{aA}	22.75±0.87^{aA}	22.75±0.87^{aA}	22.75±0.87^{aA}	22.75±0.87^{aA}
	1	22.50±0.46^{aA}	22.57±0.51^{aA}	22.60±0.53^{aA}	22.67±0.35^{aA}	22.67±0.74^{aA}	22.70±0.52^{aA}
	2	15.03±0.51^{bB}	22.21±0.25^{aA}	22.43±0.51^{aA}	22.58±0.51^{aA}	22.59±0.10^{aA}	22.66±0.49^{aA}
	4.5	11.23±0.90^{cB}	22.17±1.27^{aA}	22.37±0.34^{aA}	22.40±0.40^{aA}	22.43±0.67^{aA}	22.47±0.76^{aA}
Fiber (%)	0	5.15±0.04^{aA}	5.15±0.04^{aA}	5.15±0.04^{aA}	5.15±0.04^{aA}	5.15±0.04^{aA}	5.15±0.04^{aA}
	1	4.97±0.08^{aA}	5.13±0.06^{aA}	5.13±0.04^{aA}	5.13±0.06^{aA}	5.13±0.12^{aA}	5.15±0.05^{aA}
	2	4.60±0.10^{bB}	5.05±0.05^{aAB}	5.13±0.03^{aA}	5.13±0.03^{aA}	5.13±0.06^{aA}	5.15±0.05^{aA}
	4.5	4.07±0.15^{cC}	4.90±0.10^{bB}	5.10±0.02^{aA}	5.12±0.03^{aA}	5.13±0.06^{aA}	5.15±0.09^{aA}

*Means (±SD) with different upper-case/lower-case letters in the same line/column are different at 5% probability test. With **TST**: control polypropylene bag; **H0**: triple bagging without biopesticide; **H1**: triple bagging with 0.7% biopesticide (w / w); **H2**: triple bagging with 2.5% biopesticide (w / w); **H3**: triple bagging with 4.3% biopesticide (w / w); **H4**: triple bagging with 5% biopesticide (w / w).*

TABLE 5
EVOLUTION IN PROTEIN ENERGY CHARACTERISTIC (MOISTURE, ASH, LIPID, PROTEIN AND FIBER) ACCORDING TO TREATMENT AFTER 7 AND 8 MONTHS OF STORAGE (ON DRY WEIGHT BASIS)

Parameters	Storage time (month)	Treatments				
		H0	H1	H2	H3	H4
Moisture (%)	7	12.55±0.11^{a}	11.72±0.03^{b}	11.63±0.01^{b}	11.56±0.19^{b}	11.54±0.04^{b}
	8	14.10±0.11^{a}	12.10±0.10^{b}	12.06±0.12^{b}	12.06±0.06^{b}	11.83±0.14^{b}
Ash (%)	7	2.40±0.01^{b}	2.58±0.02^{a}	2.60±0.05^{a}	2.61±0.05^{a}	2.65±0.05^{a}
	8	2.20±0.02^{b}	2. 54±0.15^{a}	2.58±0.08^{a}	2.60±0.02^{a}	2.64±0.04^{a}
Lipid (%)	7	1.40±0.10^{b}	1.70±0.02^{a}	1.76±0.04^{a}	1.76±0.09^{a}	1.78±0.11^{a}
	8	1.18±0.03^{b}	1.69±0.10^{a}	1.73±0.15^{a}	1.74±0.05^{a}	1.77±0.06^{a}
Protein (%)	7	15.21±1.32^{b}	22.23±0.40^{a}	22.25±0.25^{a}	22.33±0.58^{a}	22.40±0.38^{a}
	8	13.63±1.89^{b}	18.14±0.99^{a}	18.50±1.30^{a}	18.98±1.38^{a}	19.12±0.82^{a}
Fiber (%)	7	4.37±0.11^{b}	5.07±0.01^{a}	5.12±0.03^{a}	5.13±0.03^{a}	5.14±0.04^{a}
	8	3.73±0.15^{c}	4.60±0.10^{b}	4.98±0.10^{a}	5.11±0.04^{a}	5.14±0.04^{a}

*Means (±SD) with different lower-case letters in the same line are different at 5% probability test. With **H0**: triple bagging without biopesticide; **H1**: triple bagging with 0.7% biopesticide (w / w); **H2**: triple bagging with 2.5% biopesticide (w / w); **H3**: triple bagging with 4.3% biopesticide (w / w); **H4**: triple bagging with 5% biopesticide (w / w).*

TABLE 6

EVOLUTION IN PROTEIN ENERGY CHARACTERISTIC (STARCH, TOTAL CARBOHYDRATE, TOTAL SOLUBLE SUGAR, REDUCING SUGAR AND ENERGY VALUE) ACCORDING TO TREATMENT AT 4.5 MONTH OF STORAGE (ON DRY WEIGHT BASIS)

Parameters	Storage time (month)	TST	H0	H1	H2	H3	H4
Starch (%)	0	53.80±0.68^{aA}	53.80±0.68^{aA}	53.80±0.68^{aA}	53.80±0.68^{aA}	53.80±0.68^{aA}	53.80±0.68^{aA}
	1	51.25±0.22^{bB}	53.43±1.16^{aA}	53.63±0.64^{aA}	53.67±0.71^{aA}	53.77±0.51^{aA}	53.80±1.37^{aA}
	2	46.22±0.95^{bB}	53.07±0.95^{aA}	53.57±0.25^{aA}	53.63±0.71^{aA}	53.70±1.18^{aA}	53.70±0.70^{aA}
	4.5	40.43±0.68^{cC}	45.57±0.65^{bB}	52.70±0.75^{aA}	53.30±0.96^{aA}	53.40±1.22^{aA}	53.66±0.78^{aA}
Total carbohydrate (%)	0	62.62±0.73^{aA}	62.62±0.73^{aA}	62.62±0.73^{aA}	62.62±0.73^{aA}	62.62±0.73^{aA}	62.62±0.73^{aA}
	1	63.22±0.52^{aA}	62.97±0.52^{aA}	62.83±0.45^{aA}	62.77±0.14^{aA}	62.76±0.68^{aA}	62.72±0.45^{aA}
	2	69.19±0.29^{bB}	63.31±0.30^{aA}	63.00±0.56^{aA}	62.84±0.46^{aA}	62.80±0.04^{aA}	62.73±0.38^{aA}
	4.5	71.23±1.02^{cB}	64.61±0.45^{bA}	64.22±0.42^{abA}	63.15±0.32^{abA}	63.10±0.63^{abA}	63.05±0.74^{abA}
Total soluble sugar (%)	0	15.89±0.19^{aA}	15.89±0.19^{aA}	15.89±0.19^{aA}	15.89±0.19^{aA}	15.89±0.19^{aA}	15.89±0.19^{aA}
	1	14.77±0.21^{bB}	15.00±0.10^{abA}	15.63±0.46^{aA}	15.70±0.70^{aA}	15.83±0.15^{aA}	15.87±0.15^{aA}
	2	10.70±0.17^{cC}	13.63±0.56^{bB}	15.57±0.11^{aA}	15.70±0.26^{aA}	15.80±0.26^{aA}	15.87±0.29^{aA}
	4.5	6.99±0.18^{dC}	10.67±0.73^{cB}	15.50±0.51^{aA}	15.50±0.56^{aA}	15.53±0.50^{aA}	15.83±0.15^{aA}
Reducing sugar (%)	0	3.12±0.02^{aA}	3.12±0.02^{aA}	3.12±0.02^{aA}	3.12±0.02^{aA}	3.12±0.02^{aA}	3.12±0.02^{aA}
	1	2.93±0.15^{aB}	3.10±0.10^{aA}	3.11±0.10^{aA}	3.11±0.04^{aA}	3.11±0.10^{aA}	3.12±0.11^{aA}
	2	2.00±0.10^{bC}	2.99±0.01^{bB}	3.10±0.06^{aA}	3.10±0.10^{aA}	3.11±0.10^{aA}	3.11±0.12^{aA}
	4.5	1.51±0.04^{dC}	2.65±0.11^{cB}	3.06±0.05^{aA}	3.08±0.06^{aA}	3.10±0.00^{aA}	3.10±0.09^{aA}
Energy (kcal/100g)	0	358.25±1.07^{aA}	358.25±1.07^{aA}	358.25±1.07^{aA}	358.25±1.07^{aA}	358.25±1.07^{aA}	358.25±1.07^{aA}
	1	356.69±0.10^{aA}	357.87±0.39^{aA}	358.08±0.86^{aA}	358.19±0.40^{aA}	358.21±0.08^{aA}	358.25±0.44^{aA}
	2	349.30±0.66^{bB}	357.62±0.12^{aA}	357.91±0.16^{aA}	357.96±0.34^{aA}	358.00±0.07^{aA}	358.06±0.24^{aA}
	4.5	339.47±1.55^{cB}	353.25±2.81^{bA}	353.91±0.25^{bA}	354.02±0.63^{bA}	354.13±0.16^{bA}	354.26±0.71^{bA}

*Means (±SD) with different upper-case/lower-case letters in the same line/column are different at 5% probability test. With **TST**: control polypropylene bag; **H0**: triple bagging without biopesticide; **H1**: triple bagging with 0.7% biopesticide (w / w); **H2**: triple bagging with 2.5% biopesticide (w / w); **H3**: triple bagging with 4.3% biopesticide (w / w); **H4**: triple bagging with 5% biopesticide (w / w).*

TABLE 7
EVOLUTION IN PROTEIN ENERGY CHARACTERISTIC (STARCH, TOTAL CARBOHYDRATE, TOTAL SOLUBLE SUGAR, REDUCING SUGAR AND ENERGY VALUE) ACCORDING TO TREATMENT AFTER 7 AND 8 MONTHS OF STORAGE (ON DRY WEIGHT BASIS)

Parameters	Storage time (month)	Treatments				
		H0	H1	H2	H3	H4
Starch (%)	7	42.27±0.95^{b}	51.47±1.18^{a}	53.00±0.20^{a}	53.30±1.04^{a}	53.43±1.00^{a}
	8	41.65±1.21^{b}	51.18±1.69^{a}	52.13±1.21^{a}	53.13±0.42^{a}	53.20±0.44^{a}
Total carbohydrate (%)	7	68.44±1.12^{a}	64.76±0.39^{b}	63.76±0.23^{b}	63.74±0.53^{b}	63.63±0.31^{b}
	8	68.89±1.79^{a}	65.13±0.85^{b}	65.13±1.37^{b}	64.61±1.36^{b}	64.64±1.04^{b}
Total soluble sugar (%)	7	8.15±0.75^{c}	13.29±0.47^{b}	15.23±0.27^{a}	15.30±0.10^{a}	15.77±0.10^{a}
	8	6.70±0.75^{c}	11.90±0.10^{b}	14.10±0.95^{a}	15.07±0.21^{a}	15.20±0.20^{a}
Reducing sugar (%)	7	2.20±0.10^{b}	3.03±0.06^{a}	3.06±0.06^{a}	3.08±0.06^{a}	3.10±0.10^{a}
	8	2.08±0.08^{b}	2.90±0.10^{a}	3.00±0.20^{a}	3.07±0.06^{a}	3.10±0.10^{a}
Energy (kcal/100g)	7	347.20±0.09^{b}	351.32±0.10^{a}	351.86±0.11^{a}	352.11±0.58^{a}	352.12±0.45^{a}
	8	340.70±0.36^{b}	350.05±0.55^{a}	350.05±0.97^{a}	350.23±0.49^{a}	351.00±0.52^{a}

*Means (±SD) with different lower-case letters in the same line are different at 5% probability test. With **H0**: triple bagging without biopesticide; **H1**: triple bagging with 0.7% biopesticide (w / w); **H2**: triple bagging with 2.5% biopesticide (w / w); **H3**: triple bagging with 4.3% biopesticide (w / w); **H4**: triple bagging with 5% biopesticide (w / w).*

TABLE 8

MATRIX OF CORRELATIONS BETWEEN BIOCHEMICAL PARAMETERS OF COWPEA SEEDS DURING STORAGE

	PRC	LPC	STC	FBC	RSC	TSC	TCC	ASC	EC	MC
PRC	1.00									
LPC	0.88	1.00								
STC	0.85	0.95	1.00							
FBC	0.90	0.93	0.92	1.00						
RSC	0.90	0.96	0.95	0.90	1.00					
TSC	0.87	0.94	0.98	0.95	0.93	1.00				
TCC	-0.96	-0.93	-0.92	-0.89	-0.95	-0.92	1.00			
ASC	0.89	0.95	0.88	0.86	0.96	0.88	-0.93	1.00		
EC	0.89	0.84	0.81	0.83	0.80	0.83	-0.90	0.81	1.00	
MC	-0.89	-0.82	-0.79	-0.82	-0.79	-0.81	0.90	-0.81	-0.99	1.00

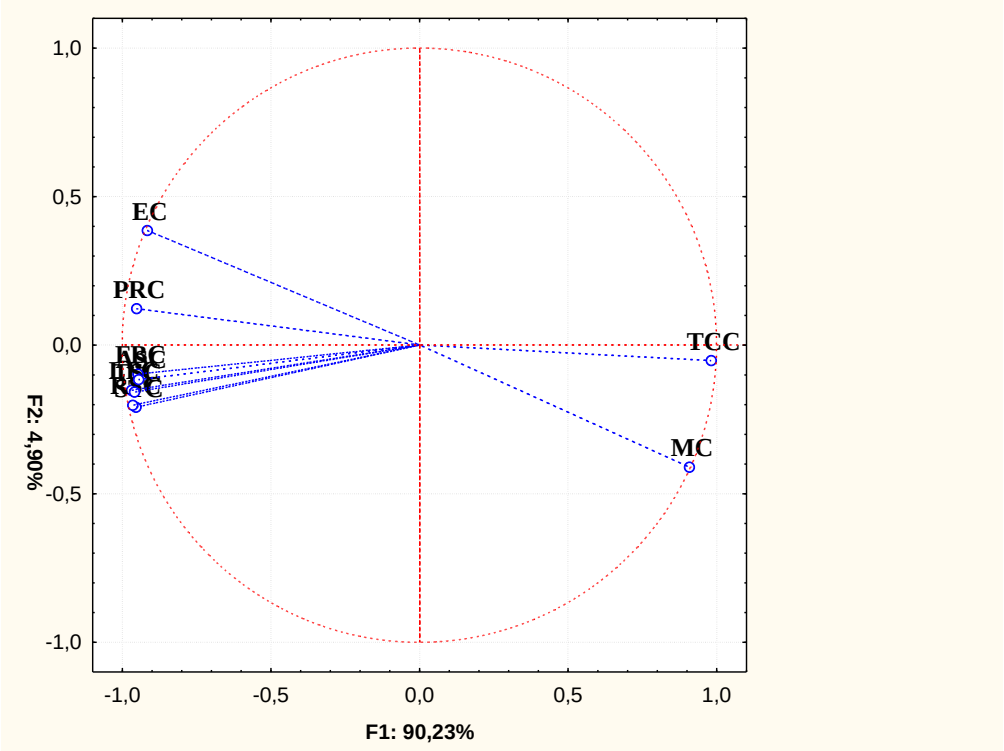
*The parameters values are significant at P=0.05; **PRC**: protein content; **LPC**: lipid content ; **STC**: starch content ; **ASC**: ash content ; **FBC**: fiber content ; **TSC**: total soluble sugar content ; **RSC**: reducing sugar content ; **TCC**: total carbohydrate content ; **EC**: energy content ; **MC**: moisture content.*

TABLE 9

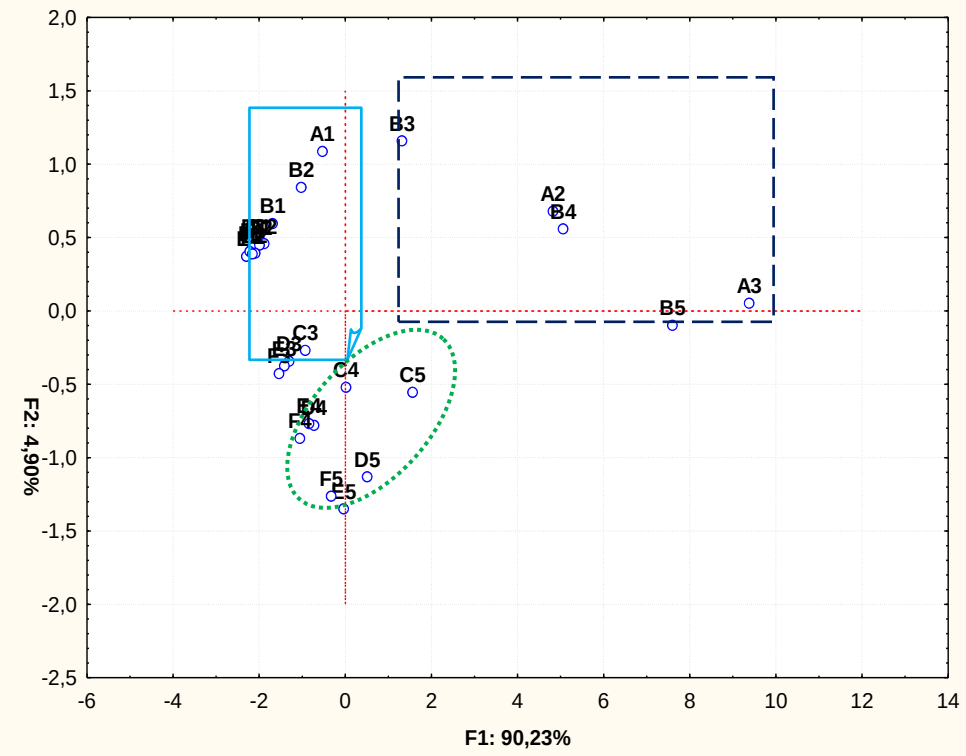
EIGEN VALUES AND CORRELATION MATRICE FACTORS OF PRINCIPAL COMPONENTS ANALYSIS WITH BIOCHEMICAL PARAMETERS OF COWPEA STORED STUDIED

Factors	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10
Eigenvalues	9.02	0.49	0.21	0.12	0.08	0.04	0.02	0.01	0.00	0.00
Variances (%)	90.23	4.90	2.11	1.20	0.83	0.40	0.20	0.11	0.18	0.00
Cumulative variance (%)	90.23	95.14	97.25	98.45	99.28	99.68	99.86	99.97	100.00	100.00
PRC	**-0.95**	0.12	0.10	-0.25	0.04	0.02	0.05	-0.04	-0.00	-0.00
LPC	**-0.97**	-0.15	0.01	0.11	-0.10	0.10	0.07	0.01	-0.01	0.00
STC	**-0.95**	-0.21	-0.14	0.09	0.12	0.04	0.00	-0.03	0.03	0.00
FBC	**-0.95**	-0.10	-0.21	-0.15	-0.16	0.02	-0.05	0.02	0.01	0.00
RSC	**-0.96**	-0.20	0.13	0.01	0.05	0.05	-0.08	-0.02	-0.02	-0.00
TSC	**-0.96**	-0.16	-0.18	0.01	0.06	-0.13	0.03	0.01	-0.02	-0.00
TCC	**0.98**	-0.05	-0.12	0.04	-0.11	-0.01	0.00	-0.08	-0.01	-0.00
ASC	**-0.94**	-0.11	0.26	0.07	-0.11	-0.10	-0.00	-0.01	0.02	-0.00
EC	**-0.92**	0.39	-0.07	0.08	-0.01	0.01	-0.01	-0.01	-0.00	-0.01
MC	**0.91**	-0.41	0.03	-0.08	0.01	0.01	0.02	0.01	0.00	-0.01

*Values of significant correlations in bold at P=0.05; **PRC**: protein contents; **LPC**: lipid content; **STC**: starch content ; **ASC**: ash content ; **FBC**: fiber content ; **TSC**: total soluble sugar content ; **RSC**: reducing sugar content ; **TCC**: total carbohydrate content ; **EC**: energy content ; **MC**: moisture content.*



(a)



(b)

FIGURE 1: Correlation drawn between the F1-F2 principal component and the protein energy characteristics (a) and the types of individuals (b) deriving from the cowpea samples studied

PRC: protein contents; **LPC**: lipid content; **STC**: starch content; **ASC**: ash content; **FBC**: fiber content; **TSC**: total soluble sugar content; **RSC**: reducing sugar content; **TCC**: total carbohydrate content; **EC**: energy content; **MC**: moisture content.

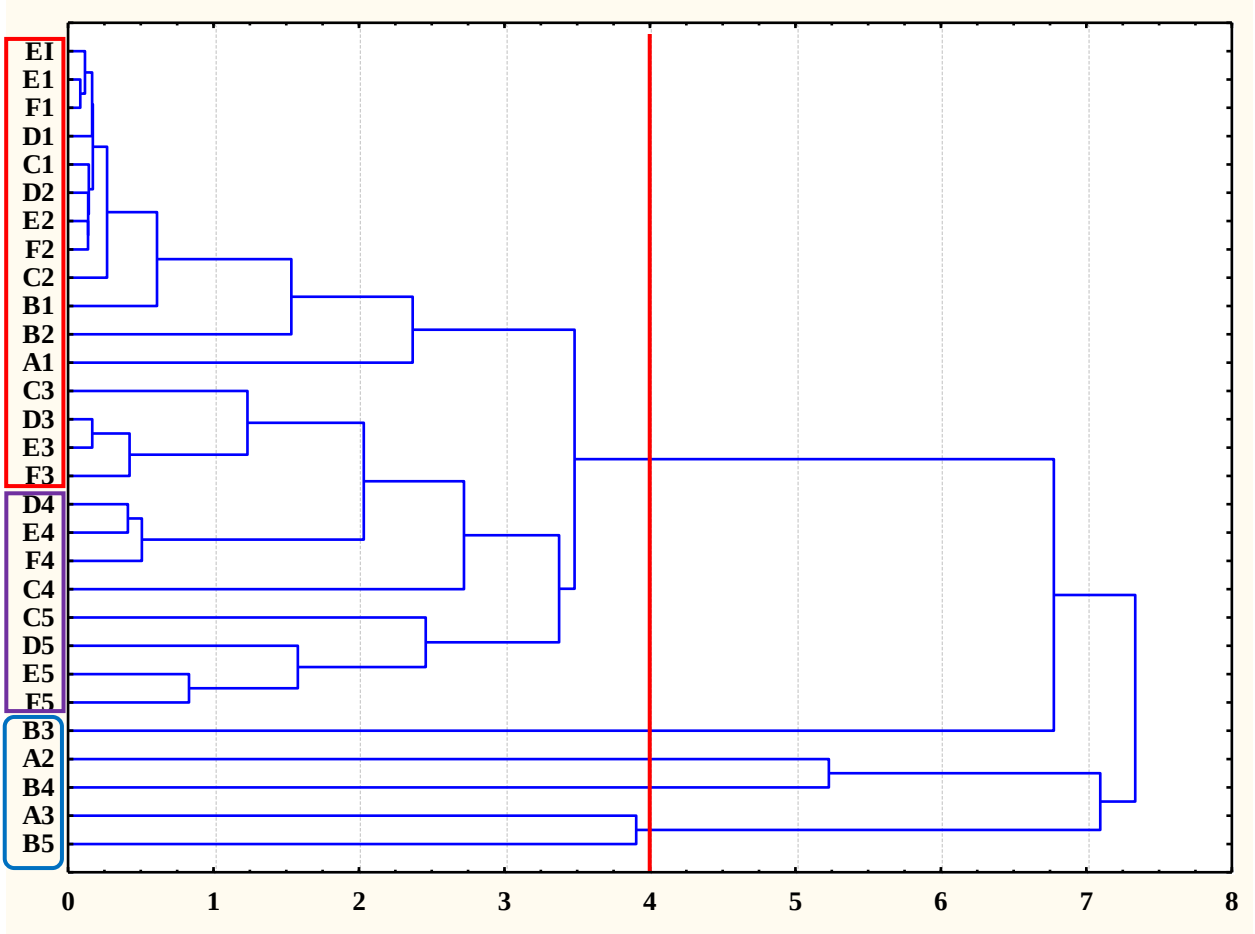


FIGURE 2: Ascending hierarchical notation (dendrogram) with the protein energy characteristics of cowpea preserved according different treatments

Ei: initial sample, **A1**: polypropylene bag at 1 month, **B1**: triple bagging without biopesticide at 1 month, **C1, D1, E1, F1**: triple bagging with 0.7%, 2.5%, 4.3% and 5% of biopesticide at 1 month **A2**: polypropylene bag at 2 months, **B2**: triple bagging without biopesticide at 2 months, **C2, D2, E2, F2**: triple bagging with respectively 0.7%, 2.5%, 4.3% and 5% biopesticide at 2 months of conservation. **A3**: polypropylene bag at 4.5 months, **B3**: triple bagging without biopesticide at 4.5 months, **C3, D3, E3, F3**: triple bagging with respectively 0.7%, 2.5%, 4.3% and 5% biopesticide at 4.5 months of storage. **B4**: triple bagging without biopesticide at 7 months, **C4, D4, E4, F4**: triple bagging with 0.7%, 2.5%, 4.3% and 5% biopesticide at 7 months of storage. **B5**: triple bagging without biopesticide at 8 months, **C5, D5, E5, F5**: triple bagging with 0.7%, 2.5%, 4.3% and 5% biopesticide at 7 months of storage.

IV. DISCUSSION

In order to maintain the protein-energy quality of cowpea seeds, the results obtained in this study show that the preservation of cowpea seeds in triple bagging systems with *Lippia multiflora* leaves is effective. The presence of *Lippia multiflora* leaves in these storage systems has allowed the moisture content of cowpea seeds to be maintained at recommended seed storage rates (8% to 12%) (Ahenkora *et al*., 1998; Madamba, 2002). These leaves would act as films above the seeds thus protecting them against dehydration, the resumption and increase of moisture. This is supported by the results of Boeke *et al* (2004) and Konan *et al* (2016), who respectively showed that the dried leaves of *Momordica charantia* and *Lippia multiflora* are effective against the weight loss of stored cowpea.

Niamketchi *et al* (2016) have also shown that the combination of the leaves of two plants, *Lippia multiflora* and *Hiptis suaveolens* makes it possible to keep the moisture content of corn kernels at a minimum during storage. On the other hand, in the TST and H0 bags, a rise in the moisture content of the seeds could be due to an increase in the air relative humidity (Di Domenico *et al*., 2015) in view of the partial impermeability of these storage systems (Lange and Wyser, 2003). This increase in seed moisture content would also be related to an increased population of fungi and insects and their metabolism

during storage. Environmental moisture is produced by the respiration processes and could affect the moisture content of the stored grain. Previous research associates significant increases in seed moisture content during storage to the bioactivities from insects and fungi (Rubasingheye *et al*., 2007, Maalekuu and Kotey, 2014). The preservation technique using triple bagging combined with the different proportions (0.7 to 5%) of biopesticide (*Lippia multiflora*) is effective in comparison with the control (single polypropylene bag) and triple bagging without biopesticide. Significant increase in seed moisture content due to humidity, insects and fungi in polypropylene bags at 2 months and in triple bagging systems without biopesticide at 7 months compared to the slowed increase in triple bagging systems with biopesticide demonstrates the effectiveness of Lippia leaves. This finding was made by Niamketchi *et al*. (2016) and Konan *et al* (2016).

The significant differences found in the macronutrients determined respectively in the polypropylene bags, the triple bagging systems with or without biopesticide, also showed the degree of effectiveness of the triple bagging systems and biopesticide (*Lippia multiflora*) in the cowpea preservation. Indeed, the hierarchical ascending classification (HAC) has shown that the macronutrient contents of cowpea seeds stored for 8 months in triple bagging systems with at least 0.7% of biopesticide remain similar overall to those of cowpea after harvest.

Results obtained from the contents of ash, fiber, lipid and protein from the various experiments are similar to the investigations of Ojiako and Kayode (2014) on cowpea seeds stored under different conditions. These authors reported a decrease in the ash, fiber and protein contents, as well as the constant maintenance of the lipid content according to the plant used during storage. Similar changes were also mentioned by Mbah and Silas (2007), Maalekuu and Kotey (2014), Sule *et al* (2016) about the evaluation of cowpea seeds quality attributes in different types of storage. But according to them, the consumption of organic compounds through metabolism of grain and associated microorganisms could increase the ash content during storage. This fact is also contradictory with the results of Houinsou *et al* (2014) which showed that cowpea seeds after 3 months of storage do not record a significant change in their ash content.

The reduction in lipids contents would derive from the degradation occurring during storage and is related to biochemical processes such as respiration, oxidation and enzymatic activity (Paraginski *et al*., 2014). Decreased of lipid contents may also be due to insects that use it as a source of energy (Maalekuu and Kotey, 2014) and fungal attacks in seeds during storage (Chatta *et al*., 2015). These results corroborate those of Aremu *et al* (2015) who found a significant reduction in the percentage of lipids contents of cowpea seed stored for 16 weeks due to microbial food that takes place within the cowpea tissue at as the duration increases. However, Ojiako and Kayode (2014) showed that storage had no effect on the initial and final fat contents of cowpea seeds treated with natural (plant) and synthetic insecticides.

The loss of protein content would be related to changes in moisture content during storage considering the opposite correlation between both parameters. Changes in protein content may result from intrinsic chemical degradation of the seeds and / or their needs (Paraginski *et al*., 2014; Stefanello *et al*., 2015). The decline in the protein content of cowpea during storage could be related to the portion of the seeds consumed by associated insects and microorganisms, since in the polypropylene control bags after 4.5 months of storage, the insects have almost totally damaged the cowpea seeds and at the same time, the protein content dropped significantly. This assumption is supported by the work of Bhushan *et al* (2016).

The starch contents decreased significantly during storage in both types of bags without biopesticide (control and H0) because of deterioration due to increased insects in stored cowpea. These observations would be linked to the rapid increase in the moisture content of cowpea. The decrease in starch content found in our study is consistent with reports by Nahla (2012), Bhushan *et al* (2016) on infested seeds.

According to them, starch plays an important role in the diets of microorganisms by supplying metabolites necessary for their different life cycles. Simic *et al*. (2007) showed that starches are reduced when exposed to the temperature of 25 ° C for 6 months of storage. In addition, Chattha *et al* (2015) showed the decrease in starch content of wheat grains at 12% moisture during storage in the straw clay bin for 12 months. According to Maréchal and Chrastil (1992), the degradation of proteins and starch can also result from Maillard oxidation reactions.

The total carbohydrates contents have undergone various changes. In polypropylene bags and triple bagging systems without biopesticide, the total carbohydrates contents increased significantly during the storage period whereas in the triple bagging systems with biopesticide, these contents increase gradually after the 7th month of storage. This leads us to assume that the abundant presence of insects in cowpea would increase total carbohydrates contents. The decrease in total and reducing sugars could be due to their consumption by microorganisms for their growth. Indeed according to Olive (2008), after hydrolysis of sugars, microorganisms specifically yeasts would prefer glucose that is directly metabolized. With such a

decrease in the main macronutrients the caloric values are logically affected and decrease during storage, as shown by the close correlations between cowpea energy value and protein and lipid contents.

V. CONCLUSION

The aim of this study was to propose to the actors of the cowpea chain in Ivory Coast inexpensive, sustainable technology, protecting the environment and human health, with a view to strengthening cowpea preservation capacities. The results of our study confirm the importance of the establishment of adequate systems for preservation of the protein-energy quality of cowpea seeds. In fact, the triple bagging systems have shown the advantage of extending the shelf life of cowpea seeds. However, the use of triple bagging systems combined with the addition of *Lippia multiflora* leaves as a biopesticide made it possible to preserve the energy-protein quality (macronutrients and energetic value) of cowpea seeds for 8 months. Thus, this biopesticide could therefore be an effective alternative in cowpea preservation as a replacement for synthetic pesticides. The method developed in our study from a biopesticide in the triple bagging systems is inexpensive and promising for Ivorian producers. However, this study needs to be deepened to preserve the micronutrients of the cowpea after storage.

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Evaluation of the CropSyst Model on Soybean (*Glycine max* L.) in the Tropics

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Abstract**—** *South Sulawesi is one of the soybean producer provinces in Indonesia. As in other tropical areas, South Sulawesi season comprises is dry and rainy seasons, so modeling of crops such as CropSyst can be very helpful in predicting planting time, providing irrigation, and applying the right fertilizer to get maximum soybean productivity. To apply the CropSyst model in the tropics such as South Sulawesi, calibration and validation of several plant parameters are required. Further calibration and validation results need to be tested to see the accuracy of predicting models. The results of soybean evaluation in South Sulawesi showed that RMSE (0.09 and 0.11), MBE (-0.01 and 0.11), MAE (0.08 and 0.11), and d (0.92 and 0.81) had values showing that CropSyst model accurately to predict grain yield of soybean in South Sulawesi.*

Keywords**— soybean, CropSyst, calibration, validation, evaluation.**

I. INTRODUCTION

CropSyst is a friendly crop simulation model used. The CropSyst model is used to look at the effects of climate, soil, and crop management systems on productivity and the environment. CropSyst simulates soil, nitrogen, plant growth and development, crop yields, residual production, soil erosion by water, and salinity [1]. The current developments that are heavily caused by the development of climate change will be a challenge for crop modeling to update the model [2]. Several studies have been done to see the level of accuracy of CropSyst model. Some of these studies suggest that CropSysts can predict convincingly the results of barley and irrigated rescue on plant yields [3], CropSyst models can be used as a means to regulate irrigation water to improve productivity with poor water quality [4], CropSyst model simulation with predictive climate can summarize the predicted outcomes going forward [5], calibration and validation of the CropSyst model for rice can precisely determine irrigation and proper fertilization [6], and evaluation of the CropSyst model on yields for cluster bean in India also shows the proximity between simulation and observation data [7].

South Sulawesi is a province in Indonesia, at $0^0$12' North Latitude - 8^0 South Latitude and $116^0$48' - $122^0$36' East Longitude. South Sulawesi which has an area of 46,083.94 km^2 divided into 21 districts and 3 cities. South Sulawesi is one of the soybean producer provinces in Indonesia, with an average productivity of 1.5 t ha^{-1} grain yield [8].

II. MATERIAL AND METHOD

The research was conducted at Jenetaesa Village, Simbang Sub-district, Maros District which is one of soybean producer in South Sulawesi, Indonesia. This study used 2 varieties of soybeans that were Anjasmoro (90 days), and Argomulyo (80 days). The experiment was made by making a plot of 2 x 3 m with 3 replications. Fertilization is done with Ponska fertilizer (N 15%, P 15%, K 15%) dose 250 kg ha^{-1} with irrigation 50 mm with interval every 10 days as much 8 times for Anjasmoro variety and 7 times for Argomulyo varieties. Other studies were conducted at Sawakong (Takalar District), Attangsalo (Soppeng District), and liliriawang (Bone District) in the form of data collection of soybean productivity. Soil attributes at the research sites are presented in Table 1, while monthly rainfall data during 2016 is presented in Table 2.

TABLE 1
SOIL ATTRIBUTES AT FOUR RESEARCH LOCATIONS

Districts	Sand	Clay	Silt	Bulk Density	Cation Exchange	pH
Jenetaesa (Maros)	24	41	35	1.270	21.28	6.80
Sawakong (Takalar)	29	17	54	1.410	17.50	6.67
Attangsalo (Soppeng)	27	40	33	1.280	33.92	7.11
Liliriawang (Bone)	42	5	53	1.610	25.68	7.8

TABLE 2
MONTHLY RAINFALL IN THE YEAR 2016 AT FOUR RESEARCH LOCATIONS

Districts	Month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Jenetaesa (Maros)	729	606	420	251	164	167	93	0	91	231	310	417
Sawakong (Takalar)	158	507	238	31	19	23	11	0	15	9	131	514
Attangsalo (Soppeng)	158	108	83	201	90	133	196	1	219	288	120	67
Liliriawang (Bone)	118	182	191	313	191	216	191	2	159	244	172	33

Treatment of irrigation is done every 10 days since sowing date with the amount of 50 mm for each time of administration. The irrigation interval along with the timetable and the amount of irrigation are presented in Table 3.

TABLE 3
MANAGEMENT IRRIGATION DURING RESEARCH

Management	Anjasmoro		Argomulyo	
	Description	Quantity	Description	Quantity
Sowing date	7 August 2016		7 August 2016	
Line spacing (cm)	20 x 40		20 x 40 cm	
1st irrigation date	7 August 2016		7 August 2016	
Irrigation (mm)		50		50
2nd irrigation date	17 August 2016			
Irrigation (mm)		50		50
3rd irrigation date	27 August 2016			
Irrigation (mm)		50		50
4th irrigation date	6 September 2016			
Irrigation (mm)		50		50
5th irrigation date	16 September 2016			
Irrigation (mm)		50		50
6th irrigation date	26 September 2016			
Irrigation (mm)		50		50
7th irrigation date	6 October 2016			
Irrigation (mm)		50		50
8th irrigation date	16 October 2016			
Irrigation (mm)		50		
Harvest date	4 November 2016		25 October 2016	
Total irrigation (mm)		400		350

For Calibration, data are used in research area at Maros District, while validation is done in 3 other locations, at Takalar, Soppeng , and Bone District with the same management. As for the evaluation of cropsyst model to see the relationship between the simulation with observation by statistically calculating Root Mean Square Error (RMSE), Mean Bias Error (MBE), Mean Absolute Error (MAE), and Index of Agreement (*d*) [9], [10], [11].

$$\text{RMSE} = \sqrt{\frac{1}{n}\Sigma(S-O)^2} \quad (1)$$

$$\text{MBE} = \frac{1}{n}\Sigma(S-O) \quad (2)$$

$$\text{MAE} = \frac{1}{n}\Sigma|S-O| \quad (3)$$

$$d = 1-\left[\frac{\Sigma(S-O)^2}{\Sigma(|S-\bar{O}|+|O-\bar{O}|)^2}\right] \quad (4)$$

explanation:

n = amount of data

S = Simulation

O = Observation

The evaluation was conducted to see if the CropSyst model can be applied to the research area for prediction. Evaluation of CropSyst model is done by performing calibration and validation on some parameters [12], [13], [14].

III. RESULTS AND DISCUSSION

3.1 Plant parameters for evaluation

For the purpose of the model, evaluation it is necessary to calibrate some aspects of crop varieties, that is in thermal time, phenology, transpiration, attainable growth, canopy growth, root, harvest, and senescence as in Table 4.

TABLE 4
PARAMETERS USED IN CROPSYST MODELS FOR SIMULATION SOYBEAN

Parameters	Anjasmoro	Argomulyo	Source
	Value	Value	
Thermal time accumulation			
Base temperature(^{0}C)	8	8	L
Cutoff temperature(^{0}C)	25	25	L
Phenology			
Degree-days emergence (^{0}C-days)	100	100	M
Degree-days begin flowering (^{0}C-days)	760	720	M
Degree-days begin filling (^{0}C-days)	1296	1235	M
Degree-days begin senescence (^{0}C-days)	1622	1478	M
Degree-days maturity (^{0}C-days)	1740	1563	M
Degree-days full senescence (^{0}C-days)	1842	1641	M
Transpiration			
Canopy extinction coefficient for total solar radiation	0.5	0.5	L
Evapotranspiration crop coefficient at full canopy	1	1	L
Leaf water potential at the onset of stomatal closure (J kg^{-1})	-1,000	-1,000	D
Wilting leaf water potential (J kg^{-1})	-1,500	-1,500	D
Maximum water uptake (mm d^{-1})	10	10	L
Attainable growth			
Above ground biomass transpiration coefficient (kPa kg m^{-3})	5	5	L
Radiation use efficiency PAR (g MJ^{-1})	2.5	2.5	C
Mean daily temperature (^{0}C)	22	22	C
Canopy growth			
Specific leaf area at optimum temperature (m^2 kg^{-1})	28	28	C
Stem/leaf partition coefficient	3	3	L
Root			
Maximum root depth (m)	1.5	1.5	M
Harvest			
Unstressed harvest index	0.3	0.3	M
Senescence			
Leaf area duration (^{0}C-days)	900	900	L

C=Calibrated, D=Default, L=literature, M=Measured [15]

3.2 CropSyst Calibration

For calibration used data of plant parameters that have been got in research during 2016, especially grain yield. The difference between the simulation and observations result is minimized by a trial and error approach. After the grain yield results between the simulation and observation being closed, then next will be validated for each calibration results in some other areas. The results of the field research (observation) along with the simulated results from CropSyst models that have been calibrated are presented in Table 5.

TABLE 5
OBSERVATION AND SIMULATION OF GRAIN YIELD CALIBRATION RESULT IN ANJASMORO AND ARGOMULYO VARIETIES

Soybean Varieties	Grain Yield (t ha^{-1})	
	Measured	Simulated
Anjasmoro	1.86	1.79
Argomulyo	1.44	1.50

Table 5 shows that in Anjasmoro variety the result of grain yield simulated is lower than the observation result, while in Argomulyo show the opposite is higher grain yield simulation compared with observation result.

3.3 Cropsyst Validation

To validate the data that has been got from field research, thus calculation of the simulation results with the observation results in three other areas. This validation result will determine whether the model can accurately predict the grain yield of the soybean or not. Validation results in the three districts in South Sulawesi are presented in Table 6.

TABLE 6
OBSERVATION AND SIMULATION OF GRAIN YIELD VALIDATION RESULT IN ANJASMORO AND ARGOMULYO VARIETIES IN SOUTH SULAWESI

Districts	Soybean Varieties	Grain Yield (t ha^{-1})	
		Measured	Simulated
Takalar	Anjasmoro	2.00	1.96
	Argomulyo	1.70	1.85
Soppeng	Anjasmoro	1.70	1.64
	Argomulyo	1.50	1.56
Bone	Anjasmoro	2.00	2.14
	Argomulyo	1.50	1.65

Table 6 shows that simulation results of Anjasmoro varieties in Takalar and Soppeng are lower than field observations, but in Bone District, the result of the simulation is higher than observation result. While for the Argomulyo variety, the simulation results are higher than the observations for the three districts.

3.4 Cropsyst Evaluation

Evaluation of CropSyst model for Anjasmoro and Argomulyo varieties was done by calculating RMSE, MBE, MAE, and *d* from each variety. The results of statistical calculations for each variety are presented in Table 7.

TABLE 7
EVALUATION PERFORMANCE CROPSYST MODEL ON GRAIN YIELD SOYBEAN IN SOUTH SULAWESI

Soybean Varieties	Parameter	Mean		RMSE	MBE	MAE	*D*
		Measured	Simulated				
Anjasmoro	Grain Yield (t ha^{-1})	1.89	1.88	0.09	-0.01	0.08	0.92
Argomulyo	Grain Yield (t ha^{-1})	1.54	1.64	0.11	0.11	0.11	0.81

The results of the evaluation in Table 7 show that the RMSE (0.09 and 0.11) and MAE (0.08 and 0.11) are so small that the CropSyst model can accurately predict the productivity of both the research site and the validation sites. RMSE and MAE are two approaches to see the difference between simulation and observation [16], [17], [18]. MBE is used to view the simulated averages below or above observation. In Anjasmoro MBE has a negative value, it shows that the simulation value is less than the observed value [19], while in Argomulyo is opposite. In the *d* (Index of Agreement) values show that both Anjasmoro (0.92) and Argomulyo (0.81) have a value close to 1, showing that the CropSyst model is suitable [20] to applied in tropical regions such as South Sulawesi, Indonesia.

IV. CONCLUSION

The results of the evaluation on the grain yield of soybean show that CropSyst model has a tiny RMSE and MAE value (close to 0), thus accurately to predict the grain yield. While the value of *d* is close to 1 which means that the model (simulation) accurately predicts the results of field research (observation). Thus it can be concluded that the CropSyst model accurately predicts grain yields in different regions of South Sulawesi, which have a tropical climate. So that, it can be concluded that the CropSyst model can be applied to tropical regions by doing calibration and validation.

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Hydrogeochemical of OuedOuerrha and OuedSra, Taounate (Rif, Morocco)

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Abstract*—The superficial waters of Taounate district are particularly affected by the pollution problem that threatens their physicochemical quality. The city of Taounate, because of its growing demography, these superficial watercourses are currently threatened by wastewaters discharges. In order to establish a diagnosis of their state of pollution, water samples were taken at two stations on OuedOuerrha and two others on its tributary OuedSra, to make a comparison between these two watercourses.*

The physicochemical characterization of downstream stations, especially in OuedSra, shows high levels in terms of BOD_5 (180 mg/L), COD (288 mg/L), and MES (152 mg/L), with a pH of 8,00 and a decrease in dissolved oxygen levels (4,8 mg/L) due essentially to urban discharges from the city of Taounate.

Otherwise, the influences of liquid discharges would certainly lead to the degradation of the quality of these waters. This situation may be aggravated by climate change, whose consequences could have adverse effects on the potential of water resources, both in terms of quantity and quality.

Keywords*—*Morocco, OuedOuerrha, OuedSra, Taounate, Wastewater.

I. INTRODUCTION

In Morocco, country with semi-arid climate, water resources are quite low.Several surface water have problems with the degradation of their quality. In the Taounateregion, these waters have a fairly high degree of pollution especially at the downstream stations of these watercourses, essentially due to liquid wastewater discharges.

Lack of awareness among the population about the protection of the environment, the rapid growth of agglomerations, as well as the uncontrolled discharges of margins, in these two watercourses, mainly OuedOuerrha or often dumped in sanitation sewers without any treatment, contain free fatty acids and phenolic compounds in high concentrations ranging from 4 to 15 g/L [1]. All this certainly contributes to an imbalance of the aquatic environment and generates polluting elements, may change their physicochemical characteristics.

In this context, the purpose of our study is to determine the hydro-chemical parameters of OuedOuerrha and its tributary Oued Sra. To determine the causes contributing to the degradation of these two watercourses and then measure their degree of pollution.

II. MATERIAL AND METHOD

2.1. Geographical setting

The studied region is located in the central part of the rifaine chain, in northern Morocco, in the Sebou watershed and specifically in the Ouerrha basin (Fig. 1). It is part of TaunateAïnMediouna sector. This region is between the Senhaja-Rheddou massif in the east and the Tabouda-Tafrannt ridge in the west and covers an area of approximately 438 Km², 35 km long, 13 km wide on average.

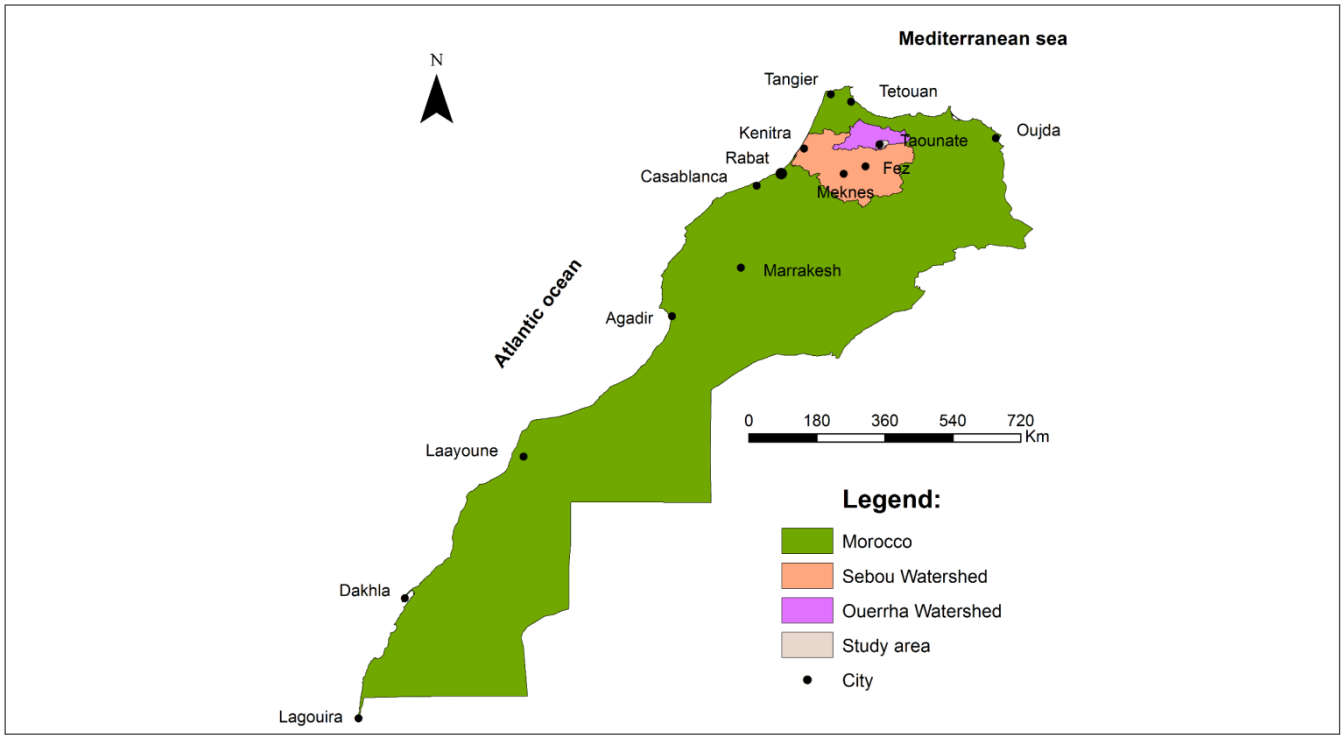


FIG. 1: LOCATION OF THE TAOUNATE STUDY AREA

2.2. Sampling campaigns

Surface water samples were selected from two main streams in the study area (OuedOuerrha and OuedSra).Four stations were prospected, the BeniOulid Bridge, Askar, Khemalcha and Sahel Mrah (Fig. 2 and 3). The various sampling campaigns were carried out during the four seasons of the year, May 2016, August 2016, November 2016 and February 2017.

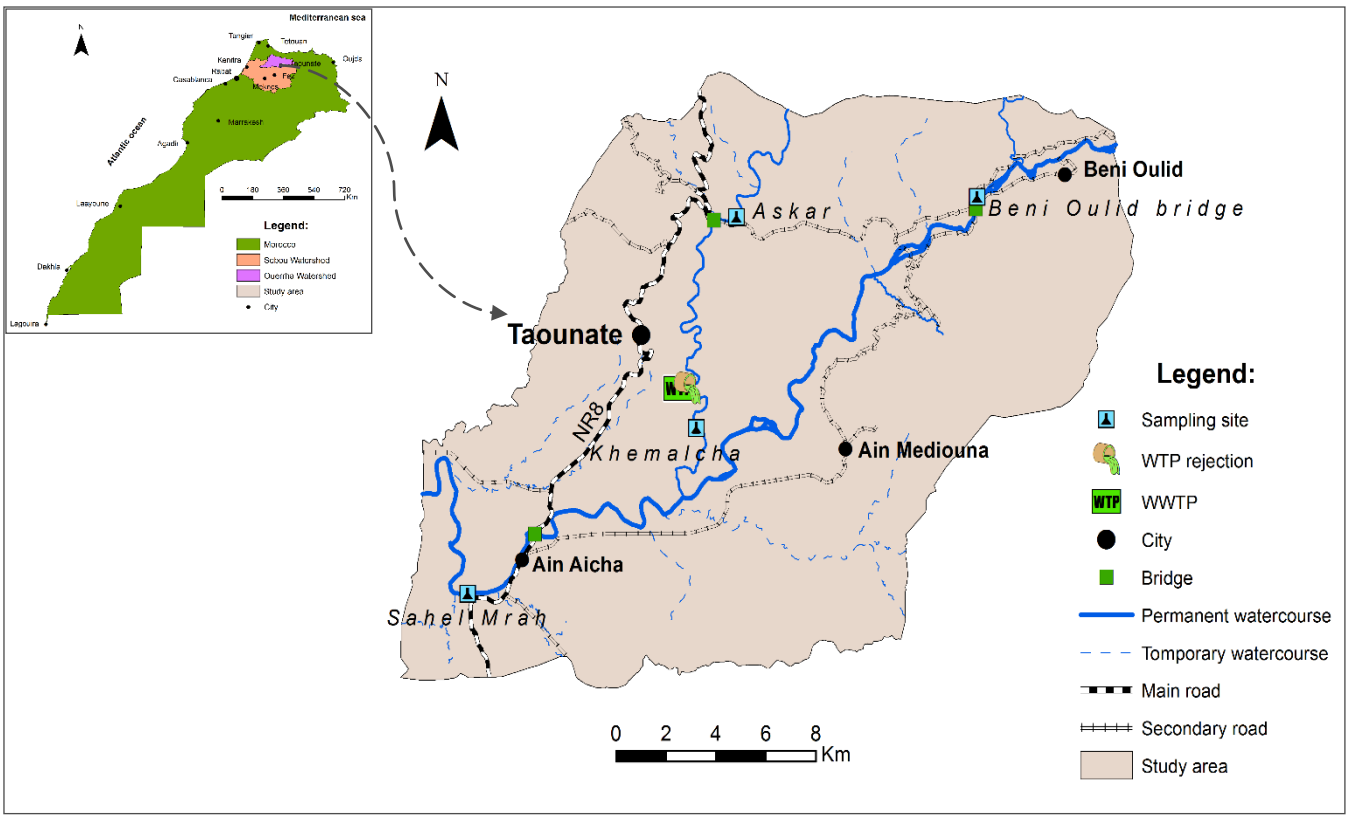


FIG. 2: LOCATION OF SAMPLING SITES.

FIG. 3: SAMPLING SITES, BENIOULID BRIDGE (A), ASKAR (B), KHEMALCHA (C) AND SAHEL MRAH (D)

2.3. Experimental procedure

The physico-chemical study of the waters focused on the determination of fourteen physico-chemical parameters. The temperature was measured "in situ" by an alcohol thermometer; The pH of the analyzed waters is measured using a pH meter Brand ADWA, Model AD1030 with combined electrode; Conductivity by OHAUS Brand Conductivimeter, Starter Model ST3100C-F; the turbidity was determined by a turbidimeter, Brand HACH, Model 2100N; the dosing of the suspended matter is done by filtration on a fiberglass filter; dissolved oxygen is measured by an EutecOximeter; the BOD5 by a BOD-meter Brand OXITOP WTW; COD by a DK6 mineralizer; the Kjeldahl nitrogen content is analyzed by a DK127 distiller; ammonium, nitrates, total phosphorus, orthophosphates and phenol index are carried out by a UV spectrometer, Brand SECOMAM, Model UVILINE 9400.

2.4. Topography

The study areais between the latitudes 34° 25' and 34° 37' North and longitudes 4° 25' and 4° 44' West,between the eastern Rif and the western Rif. The region shows a monotonous relief consisting of a multitude of hills to the south with a very low altitude of 214 m and mountains to the north which can reach 1628 m of altitude (Topographic map 1/50 000).

The lengthening of the reliefs faithfully follows the structural orientation of the Rif which draws an arch whose concavity turned towards the North.

Three sets of structures can be individualized from the analysis of topographic maps (Taounate, Dhar-Souk and Tissa) of 1/50.000:

- The Senhaja massif (Jebel Keil);
- OuedOuerrha Valley;
- The hill system of AinAicha.

Otherwise, we note the difference between the side exposed to the North whose slopes are convex or rectiline and the side exposed to the South have short concave slopes (Fig. 4).

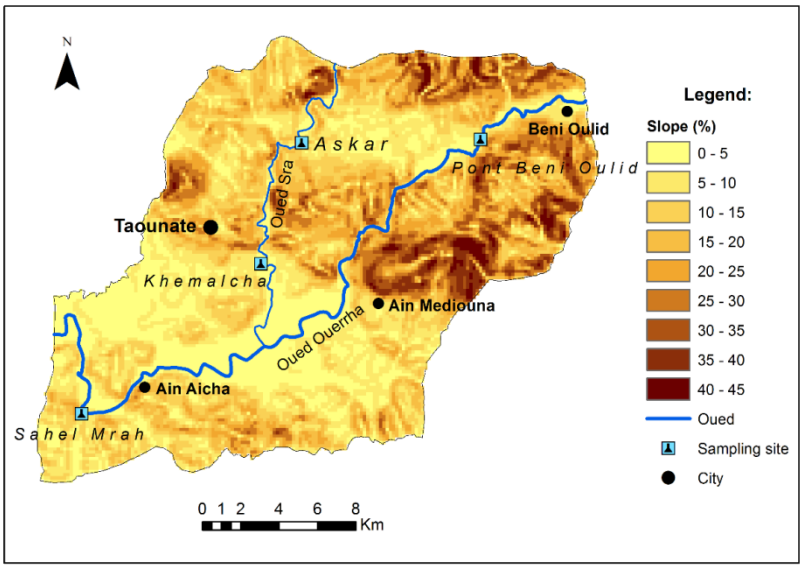


FIG. 4: MAP OF SLOPES AT 1/50.000 OF THE TAOUNATESTUDY AREA.

2.5. Geology

In the Taounate region, the geological formations (Fig. 5) of detail are complex, we have been able to distinguish several geological systems:

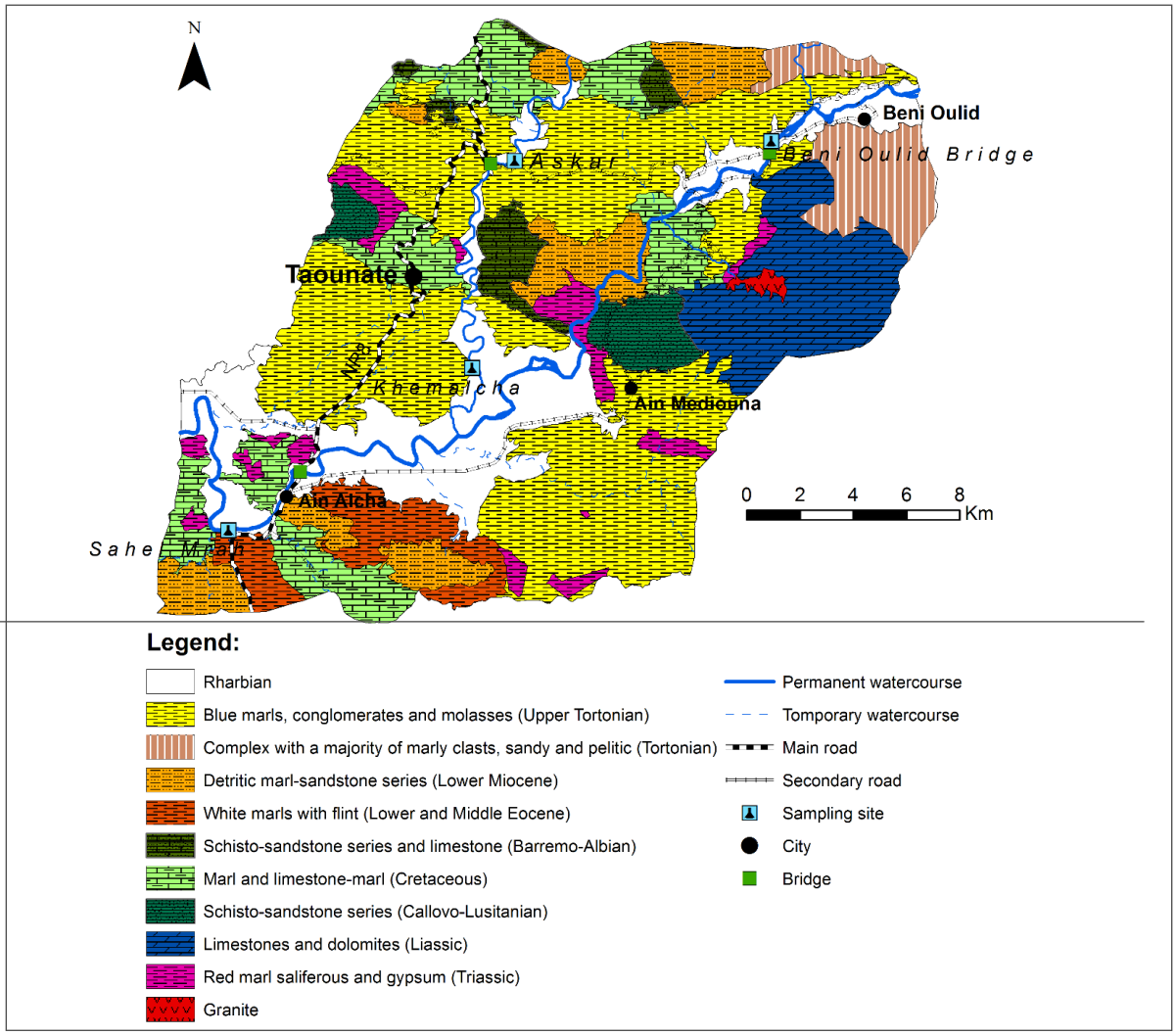


FIG. 5: STRUCTURAL GEOLOGICAL SCHEME AT 1/50.000 OF THE TAOUNATE REGION.

Geological Systems are

- **Trias:** formed essentially by salt red marl and gypsum;
- **Jurassic:** the formations are largely developed in two main facies, dolomitic limestones of the Liassic that form large massifs and a shale-sandstone flysch of Callovo-Oxfordian;
- **Cretaceous:** characterized by marls and marl-limestone, at the Aptian-Albian the detrital terrigenous character of the sedimentation is accentuated and corresponds to the flysch of Albo-Aptian;
- **Eocene:** the lower and middle Eocene are in the form of white flinty marls;
- **Quaternary:** the Quaternary evolution is reflected on the course of the big wadis, by a developed system of seven terraces;

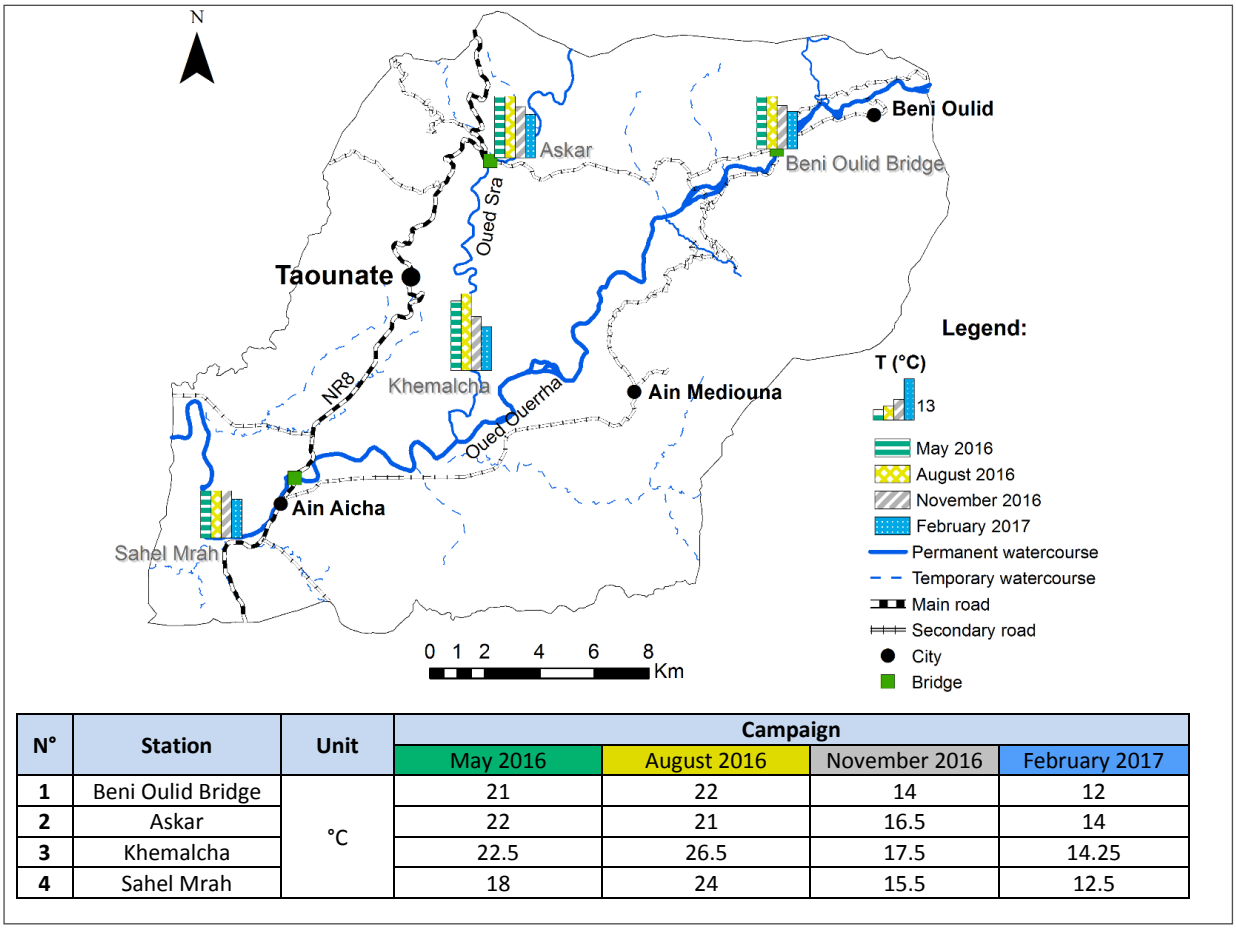
III. RESULTS AND DISCUSSION

3.1. Temperature (T)

Plays an important role in the functioning of aquatic ecosystems. Indeed, it influences the solubility of oxygen, as well as other elements. Depends on daily and seasonal variations in ambient temperature and anthropogenic discharges [2].

The temperature of the water is an essential element for the treatment or interpretation of other parameters. Since pH measurement requires knowledge of temperature, as well as the saturation of dissolved gases and temperature function [3].

The seasonal variation of the temperature shows a slight fluctuation, the lowest values are recorded during the February 2017 campaign, with a minimum of 12 ° C, the maximum value is recorded during the summer period (August 2016) of 26.5 ° C (Fig. 6). The general limit value for discharge to surface waters is 30 ° C [4]. This is closely related to air temperature and wastewater discharges, air temperature and wastewater discharges, in each station this increase can lead to the dissolution of the compounds fixing the ETM.



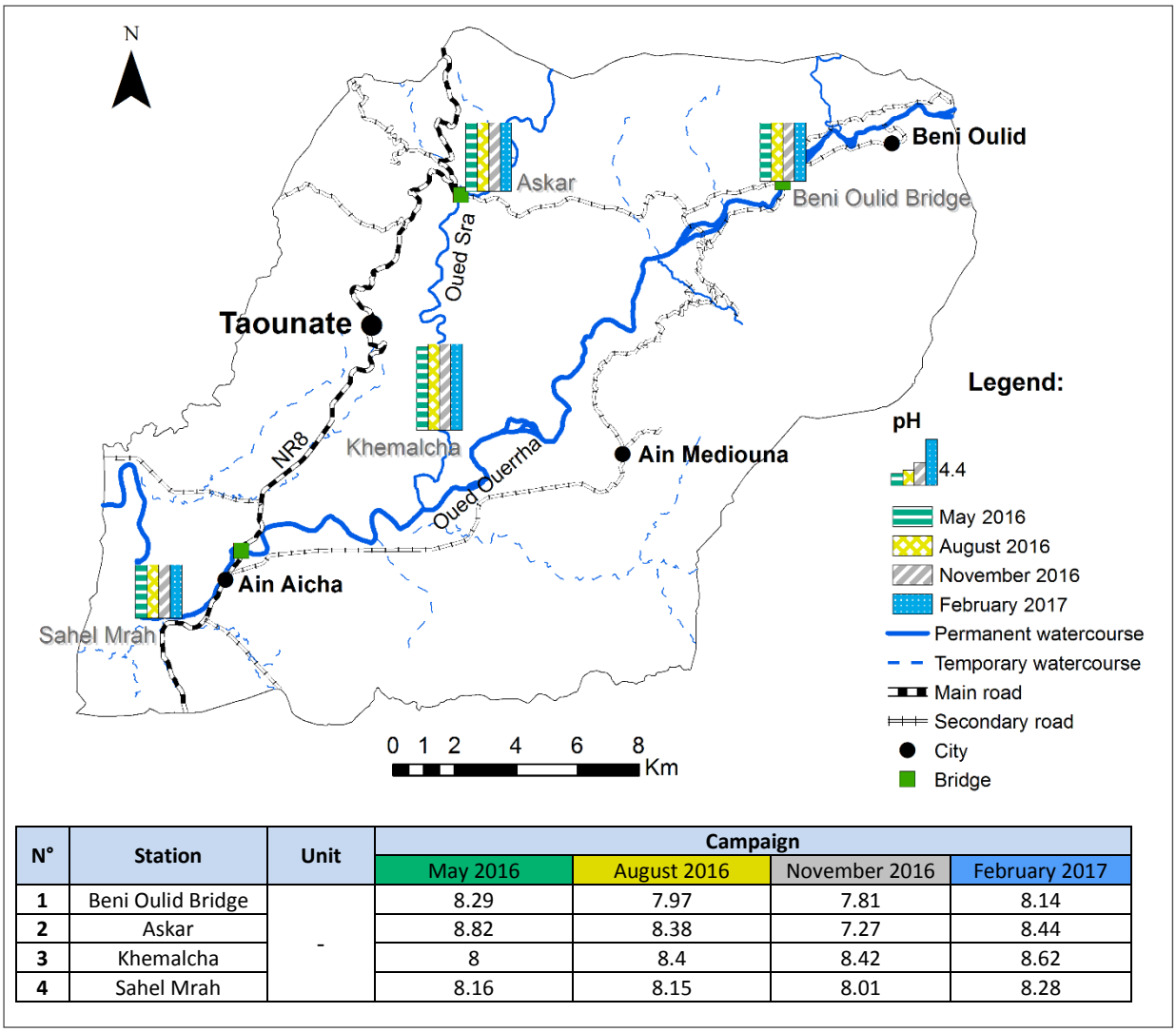
N°	Station	Unit	Campaign			
			May 2016	August 2016	November 2016	February 2017
1	Beni Oulid Bridge	°C	21	22	14	12
2	Askar		22	21	16.5	14
3	Khemalcha		22.5	26.5	17.5	14.25
4	Sahel Mrah		18	24	15.5	12.5

FIG. 6: SPATIO-TEMPORAL EVOLUTION OF THE TEMPERATURE (T)OF NATURAL WATERS OF TAOUNATE.

3.2. Hydrogen potential (pH)

The pH of the water can be used to determine the acidity, basicity or alkalinity of water. It measures the concentration of H^+ protons contained in the water. The pH of freshwater in natural environment is between 6 and 8,5. The measurement of the pH, can give information on the different chemical forms of the elements present in the water, the release of heavy metals by the solid matrix, as well as their toxicity [5].

The surface waters of the middle Ouerrha are characterized by a basic pH, since in most stations the pH is close to 8 units (Fig. 7). According to Moroccan standards for water intended for irrigation, the value must be between 6,5 and 8,5 units. According to Zhang (2014) [6] the pH of surface waters varies between 7,7 and 9,4 units. This basic character could be related to the nature of the lands crossed especially during rainy events or wastewater discharges.



N°	Station	Unit	Campaign			
			May 2016	August 2016	November 2016	February 2017
1	Beni Oulid Bridge	-	8.29	7.97	7.81	8.14
2	Askar		8.82	8.38	7.27	8.44
3	Khemalcha		8	8.4	8.42	8.62
4	Sahel Mrah		8.16	8.15	8.01	8.28

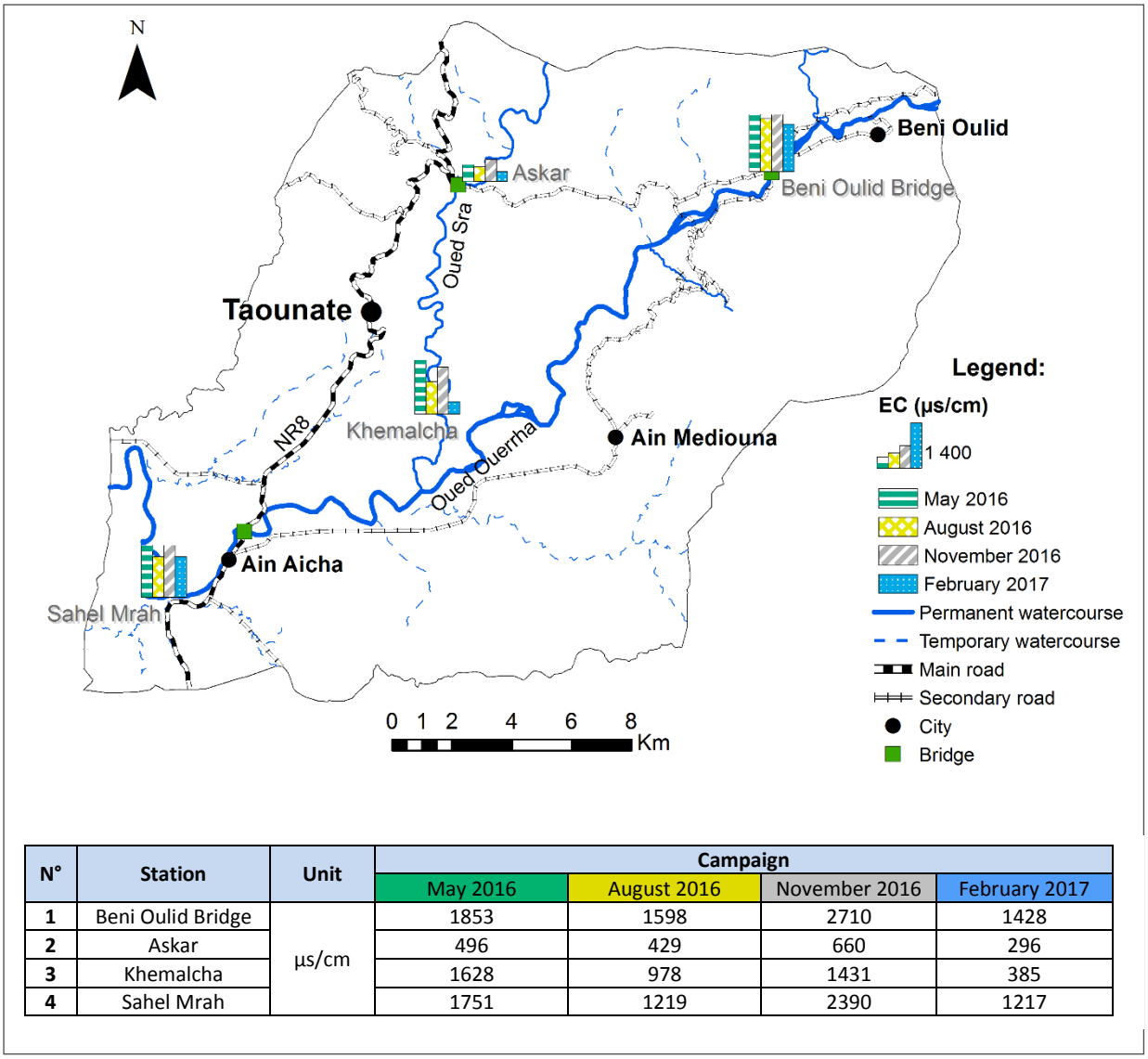
FIG.7: SPATIO-TEMPORAL EVOLUTION OF THE HYDROGEN POTENTIAL (PH) OF NATURAL WATERS OF TAOUNATE.

3.3. Electrical conductivity (CE)

Presents the ability of water to conduct an electric current and depends on the concentration of ions present in solution. The majority of natural waters are characterized by a conductivity between 10 and 1000 µs/cm [7].

The conductivity of a watercourse depends on the drained substrate, the least mineralized waters drain quartzose sandstones and granites, while the most mineralized waters drainevites rich in halite or gypsu, while the most mineralized waters drain evaporites rich in halite or gypsum. The conductivity of surface waters is generally less than 1500 µs/cm [8].

OuedOuerrha is characterized by strong mineralization especially in the upstream part (BeniOulid Bridge Station), the maximum value is recorded in November 2016 (2710 µs/cm) (Fig. 8), this value is greater than that determined by Zhang (2014) [6], of 2340 µs/cm raised in surface water. The increase of the conductivity and subsequently the ionic forces of the waters and by ion exchange, allows the release of adsorbed metals on sedimentary particles [9].



N°	Station	Unit	Campaign			
			May 2016	August 2016	November 2016	February 2017
1	Beni Oulid Bridge	µs/cm	1853	1598	2710	1428
2	Askar		496	429	660	296
3	Khemalcha		1628	978	1431	385
4	Sahel Mrah		1751	1219	2390	1217

FIG.8: SPATIO-TEMPORAL EVOLUTION OF ELECTRICAL CONDUCTIVITY (EC)OF NATURAL WATERS OF TAOUNATE.

3.4. Color

It is an organoleptic parameter related to the presence of dissolved or dispersed elements in the colloidal state [10].The color of the water is due to the absorption of certain wavelengths of the normal light radiation of the dissolved substances.To substances that absorb white or ultraviolet light, to fluorescence [11], to the presence of suspended solids and finally to the preferential dispersion of shortwave radiation by small suspended particles [12].

Surface waters are usually white, blue, green or brown depending on the color of the suspended particles that reflect light. In Khemalcha, the color of the water downstream of OuedSrâ is greenish, mainly from wastewater discharges (Table 1). On the other hand, in BeniOulid Bridge and Sahel Mrah stations is sometimes brown, generally due to the opening of the Asfelloudam valves and OuedOuerrha flows during the flood periods. Usually, the color of the water has no change in the quality of the water; it is eliminated by flocculation [13].

TABLE 1
COLORS OF SURFACE WATERS OF TAOUNATE.

Coler / Station	Campagne			
	May 2016	August 2016	November 2016	February 2017
Beni Oulid Bridge	Blue	Brown	White	Brown
Askar	Blue	Blue	White	Blue
Khemalcha	Greenish	Pale green	Pale green	Pale green
Sahel Mrah	Brown	Brown	Blue	Brown

3.5. Turbidity

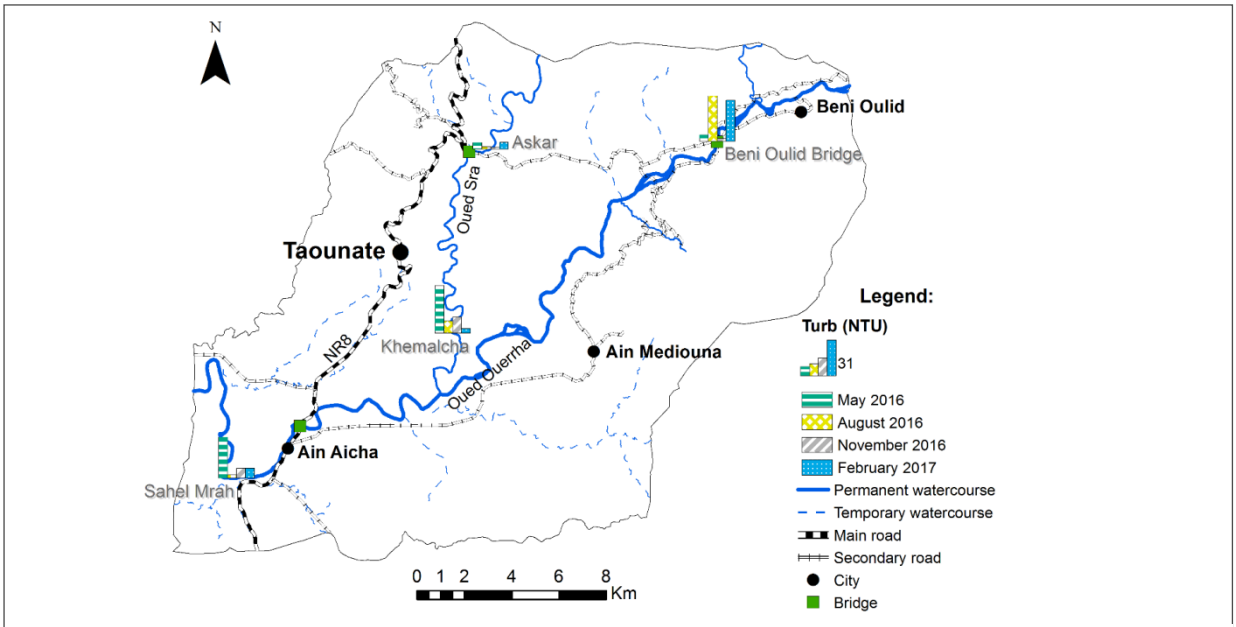
Characterizes the clarity of water or its transparency, by the presence of suspended matter undissolved in water, that comes from the erosion or leaching of agricultural lands that are causing the water trouble.

In stagnant waters (lakes), turbidity is due to colloidal or fine dispersions. However in fast flowing rivers, particles are characterized by a larger size, since most particles are inorganic in the watercourse [14].

The high turbidity value recorded in the BeniOulid Bridge station during the summer period is due to the Asfellou Dam water (61,9 NTU), consequently, the waters downstream of OuedOuerrha become trouble (Table 2 and Fig. 9).As against, those recorded in the Khemacha and Sahel Mrah stations are due to wastewater discharges from the TaounateWWTP.

TABLE 2
THE DIFFERENT TURBIDITY CLASSES IN NTU [15].

Turbidity	Water type
$NTU < 5$	Clear water
$5 < NTU < 30$	Slightly troubled water
$NTU > 50$	Troubled Water



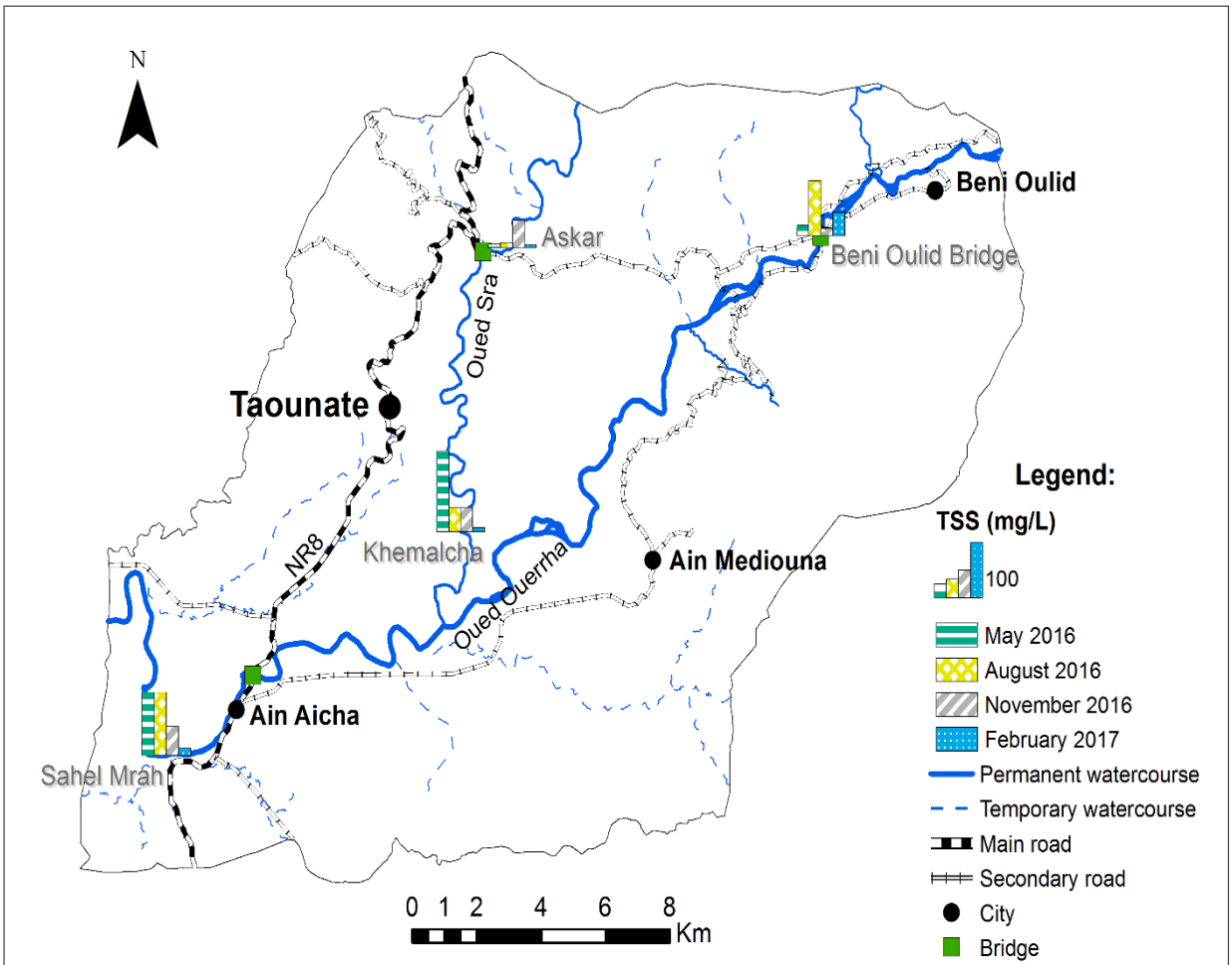
N°	Station	Unit	Campaign			
			May 2016	August 2016	November 2016	February 2017
1	Beni Oulid Bridge	NTU	5.4	61.9	2.28	35.7
2	Askar		5.5	1.97	1.54	5.64
3	Khemalcha		41.6	10.6	14.2	4.05
4	Sahel Mrah		40.3	2.8	8.43	8.59

FIG. 9: SPATIO-TEMPORAL EVOLUTION OF TURBIDITY OF NATURAL WATERS OF TAOUNATE.

3.6. Total suspended solids (TSS)

Total suspended solids represents all the mineral and organic particles contained in the water. They move in watercourse with the flow velocity, without contact with the bottom [16].The TSS depends on the nature of the lands crossed, the season, the rainfall, as well as the nature of the discharges. In fact, they are involved in the composition of water by their effects of ion exchange or adsorption, on trace elements and microorganisms [17].

During the four seasons, TSS increases considerably from upstream to downstream. In the Sahel Mrah station the levels vary between 12,5 and 206,8 mg/L (Fig.10). WHO sets a guideline level of 15 mg/L for irrigation [18]. Outside flood periods, the total suspended solids content is usually less than 25 mg/L. The high concentrations recorded in the BeniOulid and Askar stations are mainly due to the water from the Asfellou and Bouhouda dam, come largely from soil erosion. Therefore, climatic factors, mainly heavy rainfall, are the cause of erosion due to increased particle stripping forces and their transport by runoff during floods. Soil erosion is also influenced by the topography (elevation, slope, inclination) of the watershed, its lithology, the nature of the vegetation cover, and anthropogenic activities.



N°	Station	Unit	Campaign			
			May 2016	August 2016	November 2016	February 2017
1	Beni Oulid Bridge	mg/L	19	103.6	13.2	44
2	Askar		6	8.8	52	4.8
3	Khemalcha		152	46.4	46	8
4	Sahel Mrah		122	206.8	54.4	13.2

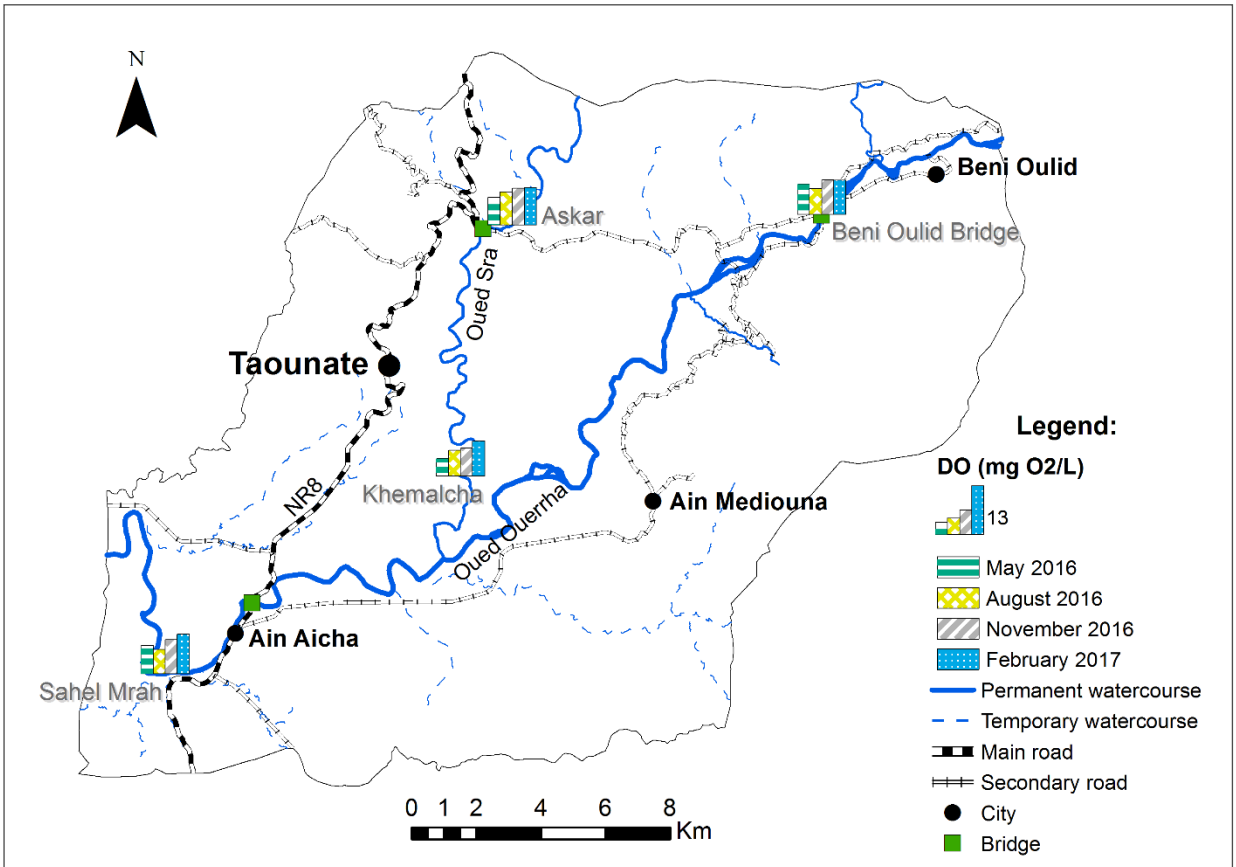
FIG. 10: SPATIO-TEMPORAL EVOLUTION OF TOTAL SUSPENDED SOLIDS (TSS) OF NATURAL WATERS OF TAOUNATE.

3.7. Dissolved oxygen (DO)

Dissolved oxygen is a key element in the control mechanisms of water pollution. It comes mainly from the atmosphere and photosynthetic activity of aquatic plants. The strong oxygenation of rivers can cause acidification of the environment by chemical or microbial oxidation of sulphides, iron or manganese with release of metals and hydrogen ions [19].

The spatio-temporal variation in dissolved oxygen shows some oxygenation during the flood period (February 2017), from 9,3 to 10,8 mg O_2/L in OuedOuerrha, and from 10,2 to 9,6 mg O_2/L in OuedSra (Fig. 11). The minimum value is recorded in the Khemalcha station during the May 2016 campaign (4.8 mg O_2/L).

In addition, the temporal evolution shows a greater oxygenation during the winter period compared to the low water level.The decrease in dissolved oxygen in the Khemalcha station is essentially due to the presence of significant amounts of organic matter resulting from the eutrophication phenomenon, or brought by the domestic discharges.



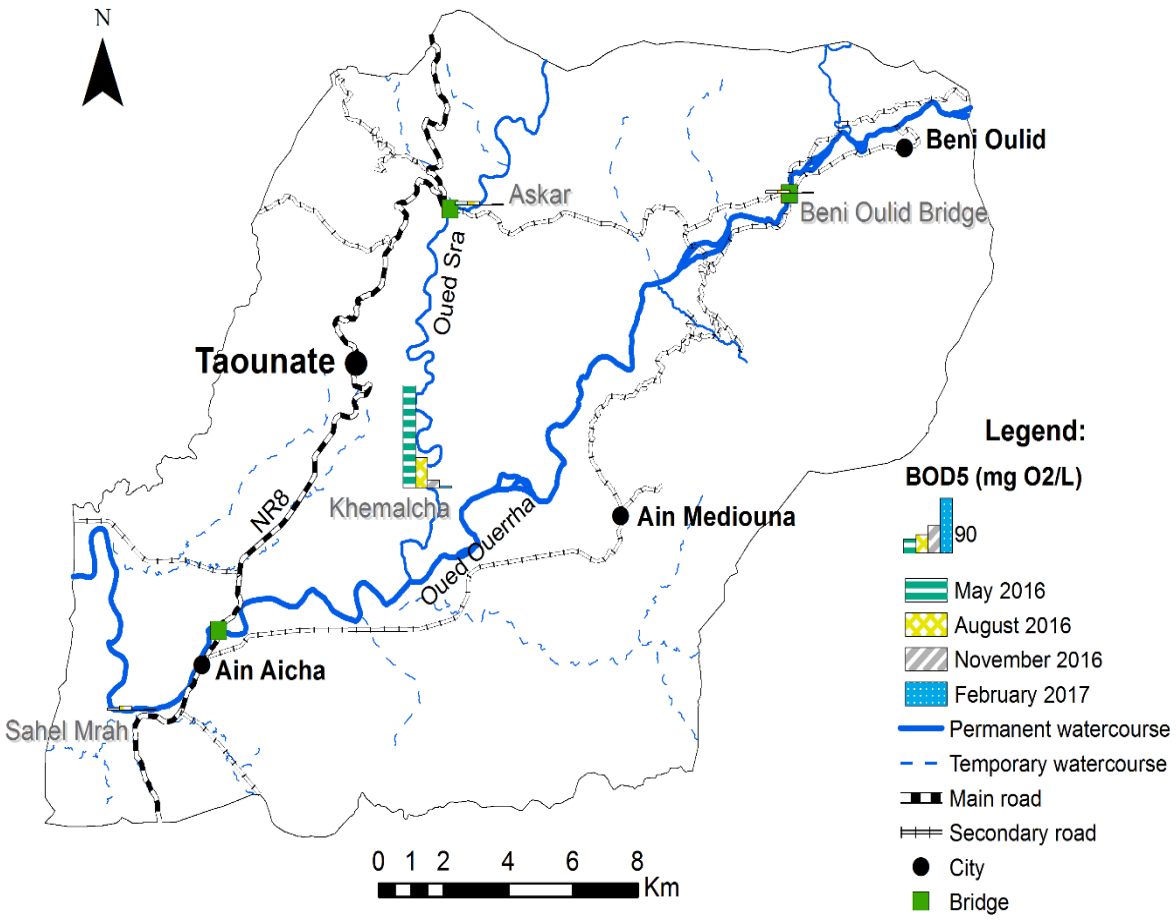
N°	Station	Unit	Campaign			
			May 2016	August 2016	November 2016	February 2017
1	Beni Oulid Bridge	mg O_2/L	8.2	6.97	9.43	9.3
2	Askar		7.5	9.04	9.96	10.2
3	Khemalcha		4.8	7.12	7.68	9.6
4	Sahel Mrah		7.7	6.68	9.3	10.8

FIG. 11: SPATIO-TEMPORAL EVOLUTION OF DISSOLVED OXYGEN (DO) OF NATURAL WATERS OF TAOUNATE.

3.8. Biochemical oxygen demand (BOD_5)

The biochemical oxygen demand represents the amount of oxygen used by the microorganisms to partially decompose or completely oxidize oxidizablebiochemicals materials present in the water for 5 days. In natural waters BOD_5 is less than or equal to 2 mg O_2/L, while in watercourses receiving domestic wastewater discharges have levels greater than 10 mg O_2/L [20].

The highest values are recorded in the Khemalcha station immediately downstream of the WWTP releases. They vary between 2 and 180 mg O_2/L, before decreasing in the Sahel Mrah station (Fig. 12), and this by the dilution effect of OuedOuerrha. According to Brion (2015), BOD_5 levels range from 1,7 to 4,8 mg O_2/L in surface water [21].



N°	Station	Unit	Campaign			
			May 2016	August 2016	November 2016	February 2017
1	Beni Oulid Bridge	mg O_2/L	4	4	0	1
2	Askar		5	5	0	1
3	Khemalcha		180	50	13	2
4	Sahel Mrah		4	7	0	1

FIG. 12: SPATIO-TEMPORAL EVOLUTION OF BIOCHEMICAL OXYGEN DEMAND (BOD_5) OF NATURAL WATERS OF TAOUNATE.

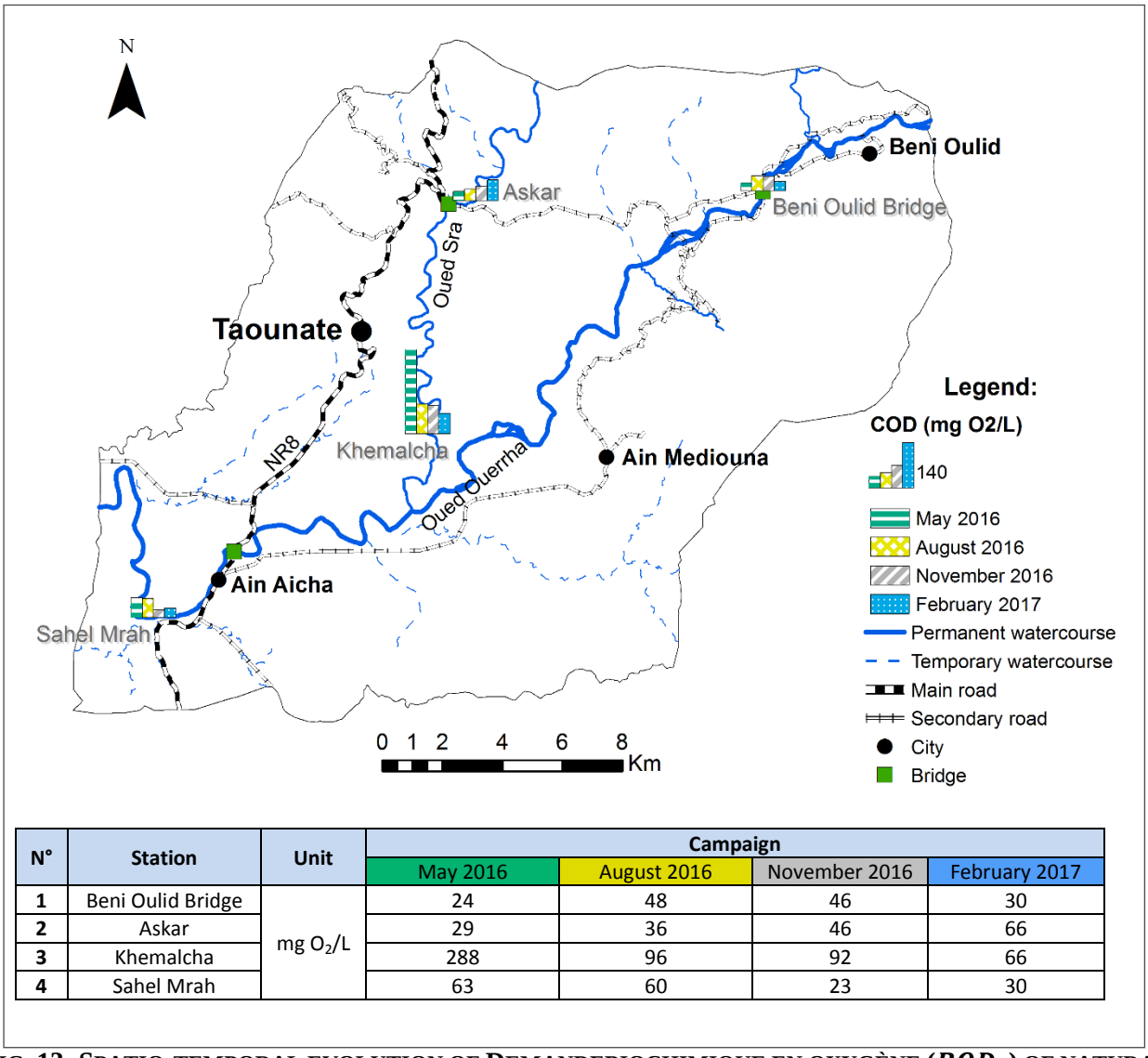
3.9. Chemicaloxygendemand (COD)

Corresponds to the amount of oxygen required for the oxidation of organic matter; plants, animal or mineral contained in the water. Chemical degradation is done by a strong oxidant of the organic compounds present in the water. COD is used to measure the concentrations of total organic matter, except some non-biodegradable compounds. It is considered as a very important parameter for the characterization of a global pollution of a watercourse.

The COD analysis results show a parallel increase with the BOD_5. In surface waters, the values vary between 23 and 288 mg O_2/L (Fig. 13). The works of Brion (2015) show contents that vary between 8,3 and 34 mg P/L [21]. The COD/BOD_5 Ratio shows that organic matter is easily or moderately biodegradable during the summer period, but during the winter period it will be difficult or even non-biodegradable (Table 3).

TABLE 3
ABILITY TO BIODEGRADE INDUSTRIAL EFFLUENT [22]

DCO/DBO_5 Ratio	Biodegradation
$COD/BOD_5 < 3$	Effluent easily biodegradable
$3 < COD/BOD_5 < 5$	Moderatelybiodegradable effluent
$COD/BOD_5 > 5$	Effluent not easily biodegradable or non-biodegradable



N°	Station	Unit	Campaign			
			May 2016	August 2016	November 2016	February 2017
1	Beni Oulid Bridge	mg O_2/L	24	48	46	30
2	Askar		29	36	46	66
3	Khemalcha		288	96	92	66
4	Sahel Mrah		63	60	23	30

FIG. 13: SPATIO-TEMPORAL EVOLUTION OF DEMANDEBIOCHIMIQUE EN OXYGÈNE (BOD_5) OF NATURAL WATERS OF TAOUNATE.

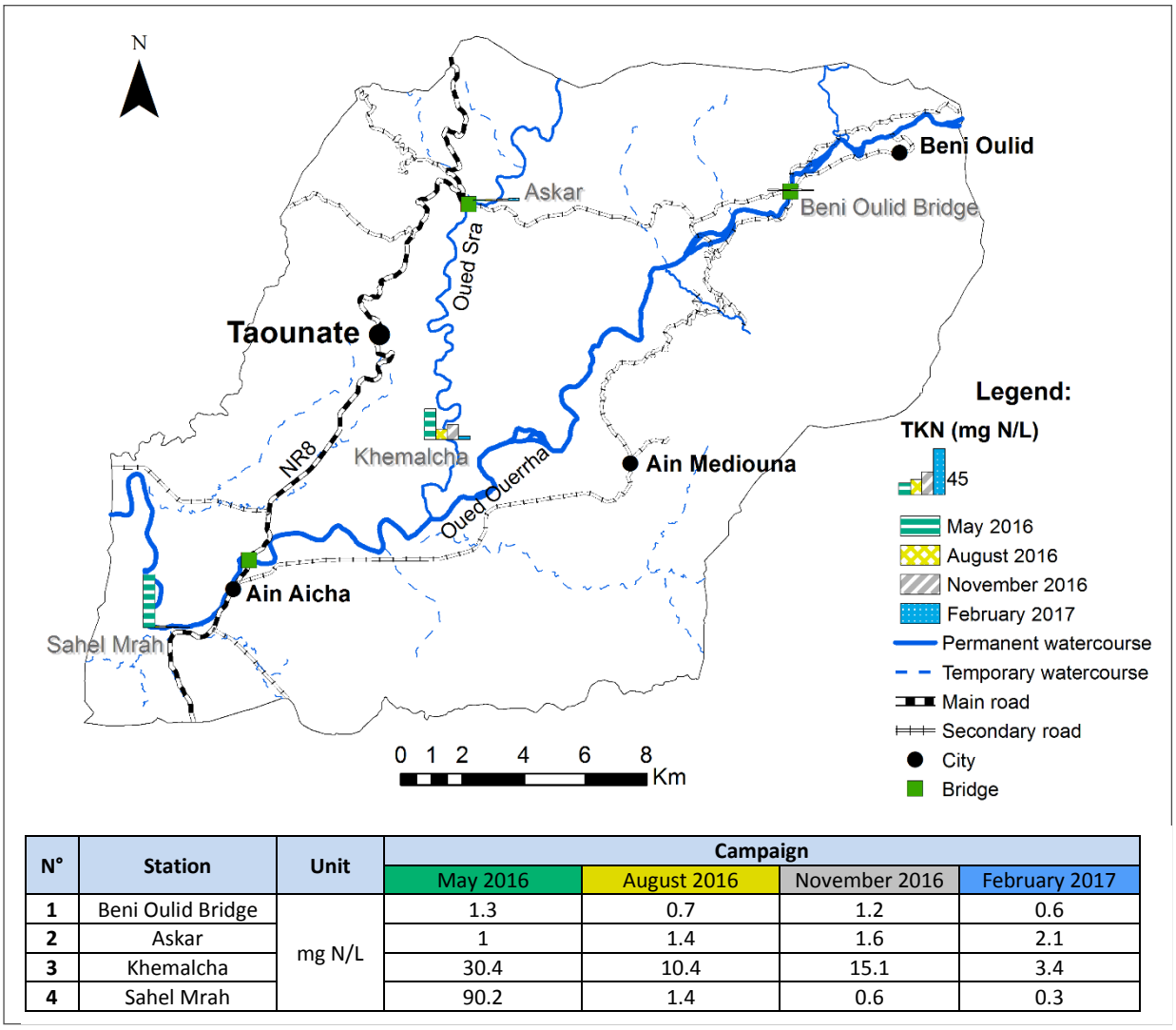
3.10. Total Kjeldahl nitrogen or (TKN)

Total Kjeldahl nitrogen is generally the sum of organic and ammoniacal nitrogen present in water (equation 1). The origin of the organic nitrogen can be the decomposition of organic waste, the human or animal organic waste and adjuvants of some detergents [23].Ammonia nitrogen can originate from plant matter in watercourses, animal or human organic matter, industrial discharges, fertilizers etc [22]:

$$NTK = N_{Org} + N - NH_4^+ \quad (1)$$

Nitrogen can also exist as nitrous and nitric nitrogen independently of nitrogen gas (neutral form). Their origin in the surface waters is related to the leaching of soils enriched in nitrogen fertilizers, to urban or industrial discharges.

The concentrations recorded in downstream stations are clearly higher than those recorded upstream, since in the Khemalcha station, the TKN contents vary between 3,4 and 30,4 mg N/L, while in the Sahel Mrah station they vary between 0,3 and 90,2 mg N/L (Fig. 14).However, the maximum discharge value in surface water is 40 mg N/L. In practice, total Kjeldahl nitrogen is an indicator of environmental pollution and its control makes it possible to follow the evolution of contaminations.



N°	Station	Unit	Campaign			
			May 2016	August 2016	November 2016	February 2017
1	Beni Oulid Bridge	mg N/L	1.3	0.7	1.2	0.6
2	Askar		1	1.4	1.6	2.1
3	Khemalcha		30.4	10.4	15.1	3.4
4	Sahel Mrah		90.2	1.4	0.6	0.3

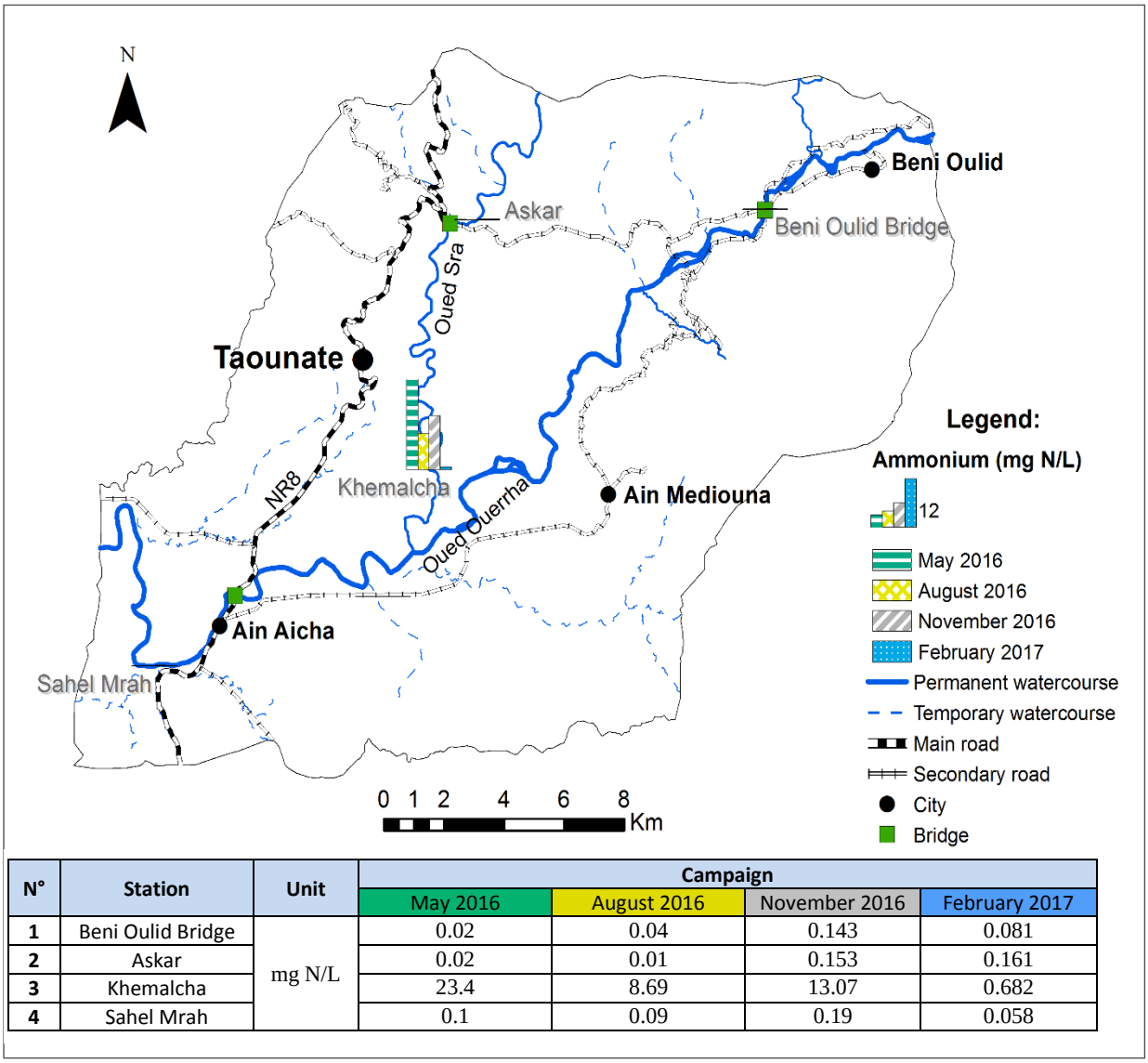
FIG. 14: SPATIO-TEMPORAL EVOLUTION OF TOTAL KJELDAHL NITROGEN OR (TKN) OF NATURAL WATERS OF TAOUNATE.

3.11. Ammonium

Provides a good indicator of watercourse pollution from domestic wastewater, residuals of industrial origin or by runoff from agricultural land.The maximum ammonium concentrations are recorded in the Khemacha station, they vary between 0,682 and 23,4 mg N/L (Fig. 15). According to studies by Yan Zhang (2014) [6], these levels in surface water range from 0,8 to 32,5 mg N/L. The presence of ammoniacal nitrogen in surface waters is related to other elements, such as nitrites and nitrates.

Purified wastewater generally contains ammonium whose content varies according to the purification process adopted, it contributes to the consumption of dissolved oxygen in the water. Ammonium levels in WWTP releases range from 4,476 to 57,05 mg N/L.

The presence of nitrites and ammonium depends on the denitrification process by oxygen consumption. Then the high content of $CO_2$and the low oxygen content increase its concentration in water. The different components of the carbon cycle include carbon fixation by photosynthesis, respiration, fermentation, methanogenesis and oxidation of $CH_4$with reduction of sulfur, iron and nitrates [24].



N°	Station	Unit	Campaign			
			May 2016	August 2016	November 2016	February 2017
1	Beni Oulid Bridge	mg N/L	0.02	0.04	0.143	0.081
2	Askar		0.02	0.01	0.153	0.161
3	Khemalcha		23.4	8.69	13.07	0.682
4	Sahel Mrah		0.1	0.09	0.19	0.058

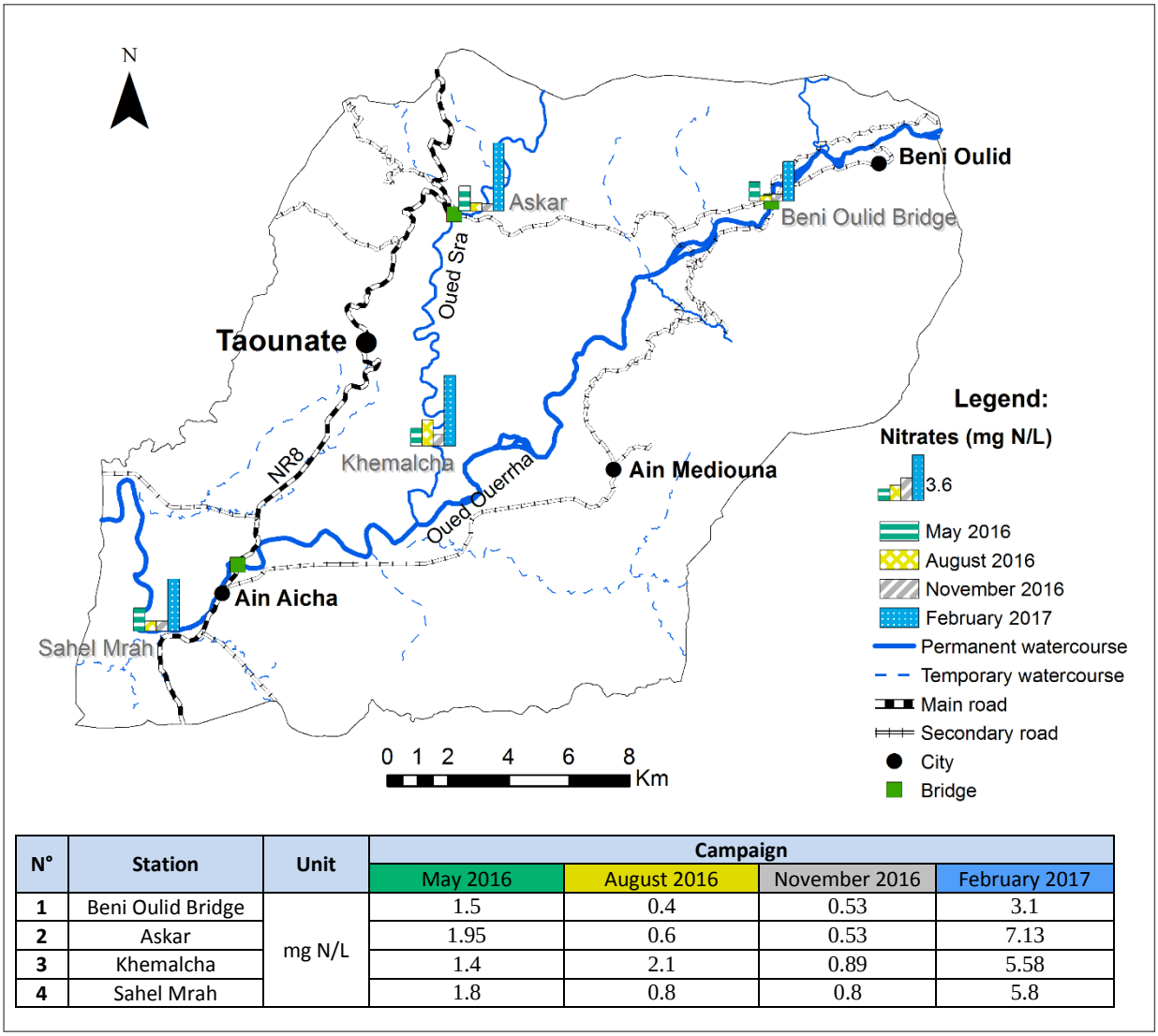
FIG. 15: SPATIO-TEMPORAL EVOLUTION OF AMMONIUM OF NATURAL WATERS OF TAOUNATE.

3.12. Nitrates

Nitrates are the most soluble forms of nitrogen in water, Indeed, their concentrations vary according to the hydrological events. They are the final stage of nitrogen oxidation and represent the highest nitrogen form of oxidation in water. Nitrates usually come from the decomposition of nitrogenous organic matter or from the dissolution of rocks or soils. In natural waters nitrates rarely exceed 0,45 mg N/L [20].

The highest nitrate fluxes and concentrations are observed in winter (February 2017), because the rains are effective and the needs of the plants fall. In the middle Ouerrha the nitrate contents vary between 0,4 and 7,13 mg N/L (Fig. 16). According to Yan Zhang (2014) [6], these concentrations in surface waters range from 0,2 to 29,6 mg N/L. In a reducing medium, devoid of oxygen, nitrates are converted into gaseous nitrogens by the denitrification process (equation 2) in poorly drained soils where the water is stagnant and depletes oxygen. This is the case for clay soils, with low permeability saturated with water [25] or for particular topographical situations of valley bottoms where water converges and saturates the soil even if it is permeable [26].

$$NO_3^- + H_3O^+ \rightleftharpoons N_2 + 3\,H_2O + {}^5/_2\,O_2 \qquad (2)$$



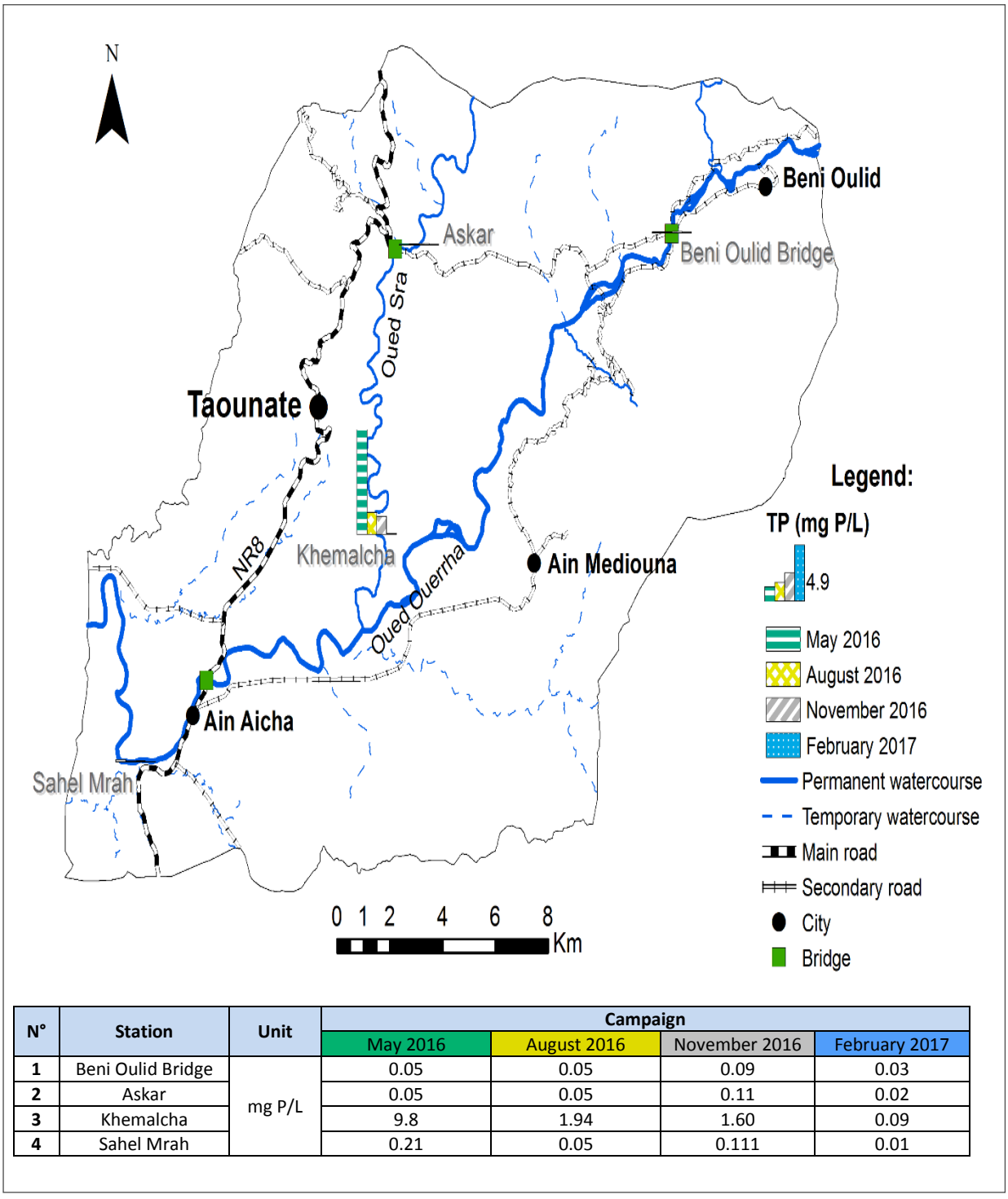
N°	Station	Unit	Campaign			
			May 2016	August 2016	November 2016	February 2017
1	Beni Oulid Bridge	mg N/L	1.5	0.4	0.53	3.1
2	Askar		1.95	0.6	0.53	7.13
3	Khemalcha		1.4	2.1	0.89	5.58
4	Sahel Mrah		1.8	0.8	0.8	5.8

FIG. 16: SPATIO-TEMPORAL EVOLUTION OF NITRATES OF NATURAL WATERS OF TAOUNATE.

3.13. Total phosphorus (TP)

In water, the total phosphorus is distributed between the dissolved phase and the particulate phase. The dissolved phase comprises two main forms the directly available mineral form present in phosphorus ion form and the organic form, mainly groups nucleic acids, phospholipids, phosphoric sugar acids and their degraded forms [27-28]. Particulate phosphorus corresponds to phosphorus compounds associated with organic matter and soil minerals, thanks to the strong affinity of orthophosphates (PO_4^{3-}) for clay minerals and for iron oxyhydroxides, with behavior similar to that of arsenic.

In the Khemalcha station downstream of OuedSra, just after the release of the Taounate WWTP, it shows the highest levels of total phosphorus that can reach 9,8 mg P/L in the May 2016 campaign (Fig. 17).According to Brion (2015), TP levels range from 0,2 and 1 mg P/L in surface water [21]. The limit value for releases into surface water is 15 mg P/L. Total phosphorus comes from effluents mostly detergents, fertilizers, decomposition of organic matter and leaching minerals from volcanic and sedimentary rocks. It is present in small quantities in unpolluted watercourses. Their decrease in the OuedOuerrha downstream station can be explained either that the phosphorus is not very mobile or is easily absorbed by soil colloids [29]. Thus, this element is mainly eliminated by mechanical erosion processes. Either their concentrations are regulated in the watercourse by several biogeochemical processes, such as bed sediment adsorption, apatite precipitation [30] and aquatic plant consumption [31].



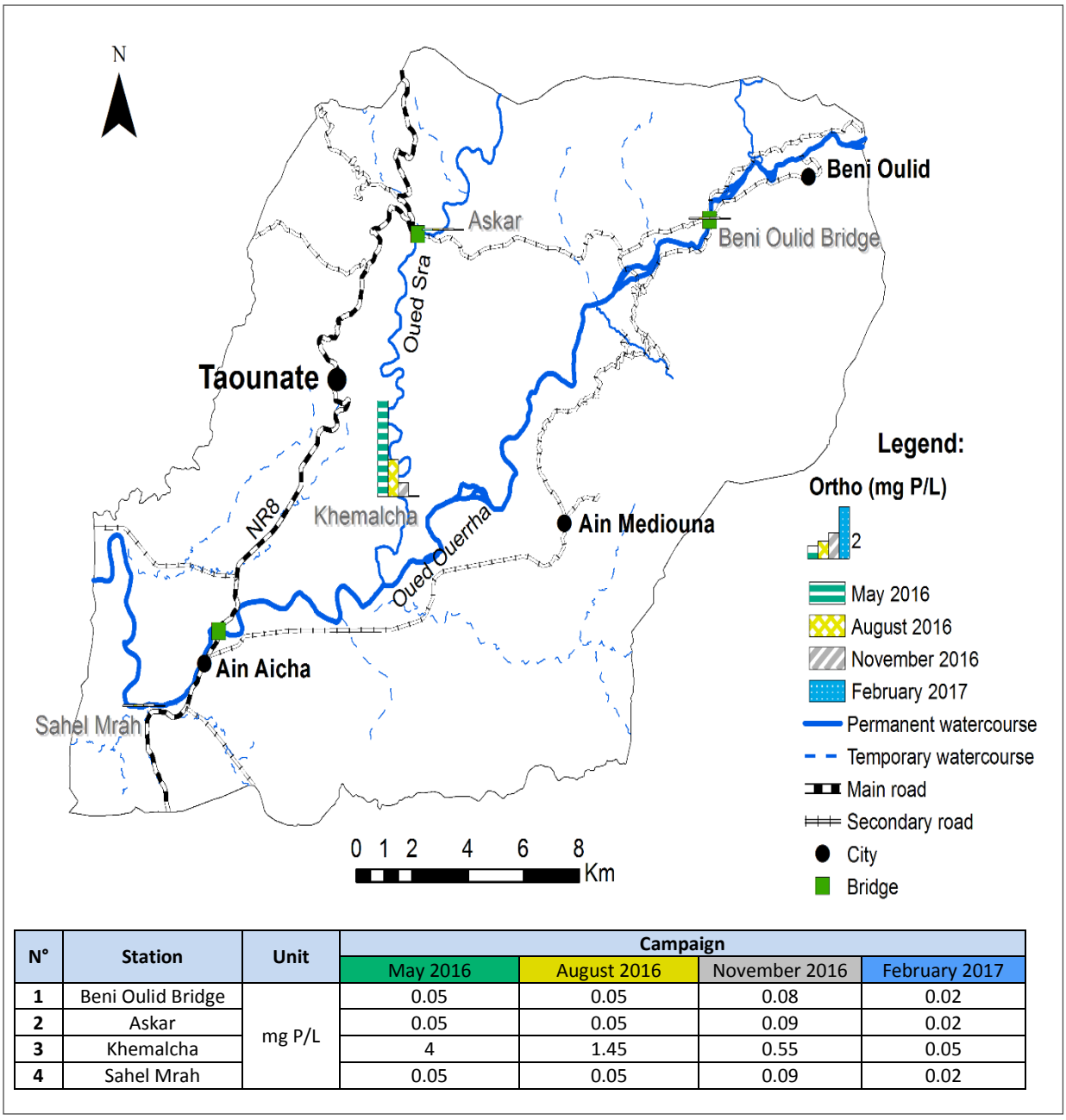
N°	Station	Unit	Campaign			
			May 2016	August 2016	November 2016	February 2017
1	Beni Oulid Bridge	mg P/L	0.05	0.05	0.09	0.03
2	Askar		0.05	0.05	0.11	0.02
3	Khemalcha		9.8	1.94	1.60	0.09
4	Sahel Mrah		0.21	0.05	0.111	0.01

FIG. 17: SPATIO-TEMPORAL EVOLUTION OF TOTAL PHOSPHORUS (TP) OF NATURAL WATERS OF TAOUNATE.

3.14. Orthophosphates

Orthophosphates come from part of the hydrolysis of inorganic phosphate and organic phosphorus. They can result from washing and cleaning products, industrial waste (slaughterhouses, specialized industrial and chemical laundries, etc.) and agricultural waste [32].As nitrates are a major nutrient plant and can cause their proliferation from 0,2 mg P/L. They constitute the limiting element of eutrophication phenomena [23].

The spatio-temporal variation of orthophosphates in surface waters shows very high levels in the Khemalcha station with slight fluctuations, ranging from 0,05 to 4 mg P/L (Fig. 18).



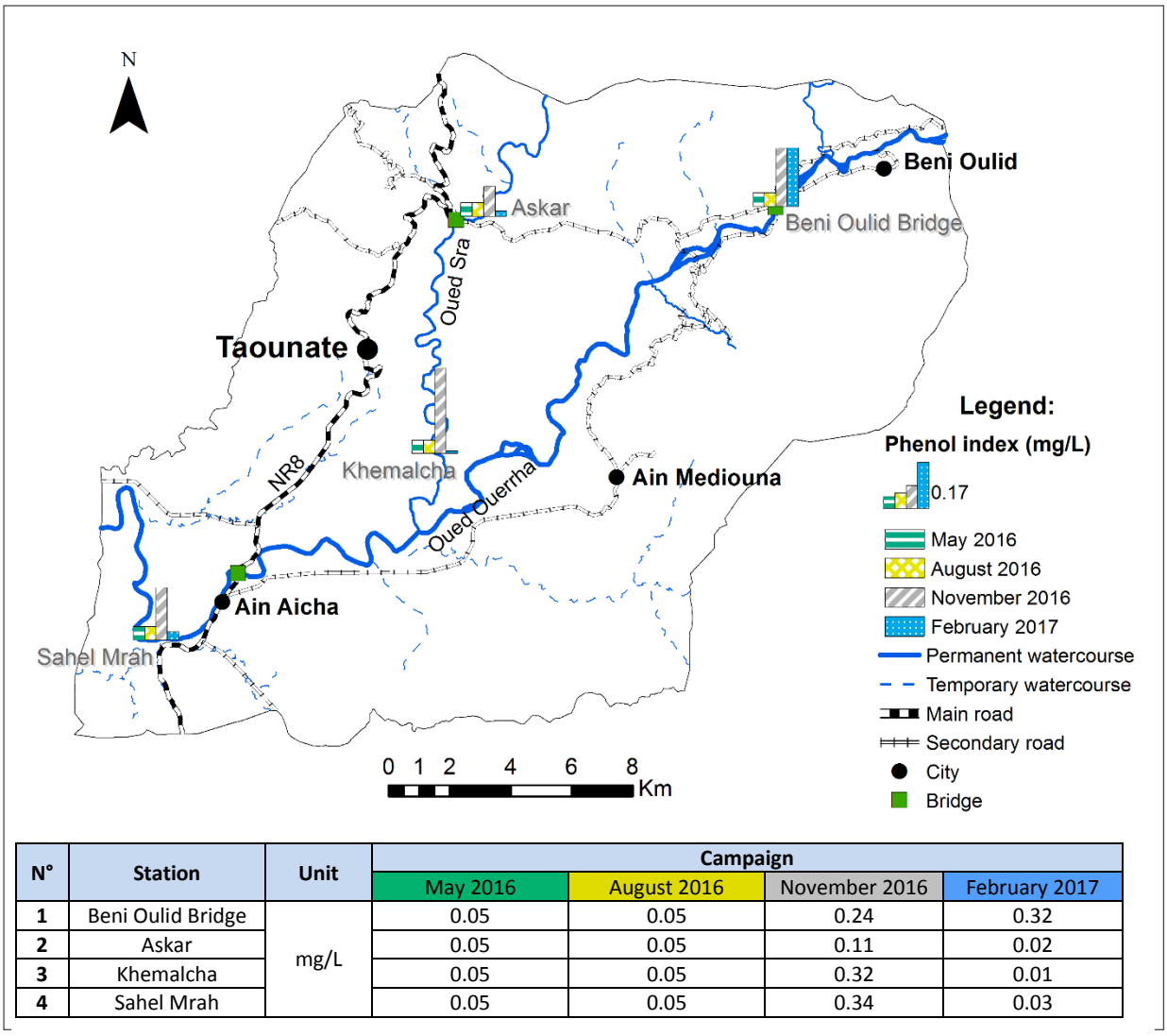
N°	Station	Unit	Campaign			
			May 2016	August 2016	November 2016	February 2017
1	Beni Oulid Bridge	mg P/L	0.05	0.05	0.08	0.02
2	Askar		0.05	0.05	0.09	0.02
3	Khemalcha		4	1.45	0.55	0.05
4	Sahel Mrah		0.05	0.05	0.09	0.02

FIG. 18: SPATIO-TEMPORAL EVOLUTION OF ORTHOPHOSPHATES OF NATURAL WATERS OF TAOUNATE.

3.15. Phenol index

Usually refers to as phenol index is a set of hydroxylated compounds of benzene. Its presence in water has most often, originated from industrial pollution (Huileries). These products oxidize weakly; they bind little and filter easily [22]. The margins are characterized by an acidic pH of 3 to 5 units and a very high electrical conductivity. They can be considered as a complex charged with organic and mineral matter [33].

In November 2016 the results show very high concentrations in surface water compared with other campaigns (0,35 mg/L) (Fig. 19), The general limit value for rejection to surface waters is 0,5 mg/L. This increase is mainly due to effluent rejection from huileries (Margins), their release into aquatic environments leads to a decrease in the concentration of dissolved oxygen, since these phenolic compounds oxidize easily with the oxygen of the medium, which renders the environment unbreathable with asphyxiation of all aquatic life. This phenomenon therefore leads to a degradation of the quality of surface water by inhibiting the development of microorganisms, especially bacteria [34]. Consequently, the natural self-purification capacity would be limited.



N°	Station	Unit	Campaign			
			May 2016	August 2016	November 2016	February 2017
1	Beni Oulid Bridge	mg/L	0.05	0.05	0.24	0.32
2	Askar		0.05	0.05	0.11	0.02
3	Khemalcha		0.05	0.05	0.32	0.01
4	Sahel Mrah		0.05	0.05	0.34	0.03

FIG. 19: SPATIO-TEMPORAL EVOLUTION OF PHENOL INDEXOF NATURAL WATERS OF TAOUNATE.

IV. CONCLUSION

After the analysis of the different physico-chemical parameters carried out on the four sampling stations of the surface waters, have shown that OuedOuerrha and its tributary OuedSra are polluted rivers in downstream stations. However, the pollution parameters observed in the Khemalcha station, downstream from the OuedSrâ, show high concentrations of BOD_5, COD, ammonium, total phosphorus and orthophosphates, essentially due to the rejection of the WWTP from the city of Taounate.

The results of the phenol index represent high levels in November and February (trituration period of margins). Indeed, this increase depends on the nature of the rejections of the margins, the variability of the type of olive, of their maturation according to the season of collection, the procedure of the extraction of olive oil and the climatic conditions.

Finally, it is recommended that several initiatives be put in place when the reuse of wastewater when treating margins:

- Reuse of all or part of the wastewater in irrigation, would reduce the quantitative and qualitative human pressure on the water resources;
- The watering of green spaces and urban landscaping also allowed people to have a better living environment;
- Installation of several natural lagoon treatment plants near major agglomerations, as the region does not contain greatfactories producing toxic chemicals or heavy metals;

- Water saving associated with the reuse of wastewater would allow sustainable management of these water resources;
- Margins treatment processes, consisting of trapping, concentrating or transforming polluting substances to reduce the polluting characteristics of industrial effluents before rejection;
- Finally, construction of sufficient basins of accumulation of margins in the province-wide production rate.

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Detection of Paramyxovirus, Reovirus and Adenovirus Infection in King Snakes (*Lampropeltis triangulum* spp.) by Transmission Electron Microscopy and Histopathology Techniques.

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***Abstract*— —** *Viruses diverse occur worldwide in reptilian. Paramyxoviruses that infect reptiles belong to Paramyxoviridae family and Ferlavirus genus and are one of the major agents responsible for causing pneumonia in snakes. Reptilian adenovirus has already been documented in various species of snakes, associated with liver, gastrointestinal, respiratory and central nervous system disease. Reptilian orthoreovirus has been demonstrated in several species of reptiles associated with sudden death, central nervous system disorders, skin lesions and pneumonia. In this study 3 kingsnakes (Lampropeltis triangulum spp), from a breeding in Rio de Janeiro, RJ, Brazil, presented a variable clinical picture and death. Feces and organ fragments were processed by the transmission electron microcopy (negative staining) and histopathology (H & E) techniques. By the negative staining, paramyxovirus-like particles, pleomorphic roughly spherical or filamentous, ranging in diameter from 100 to 500 nm, containing internal "herring-borne" nucleocapsid and an outer envelope covered by spikes, were visualized in all samples of the feces and fragments of organs examined. In samples of the small intestine, stomach, pancreas and spleen fragments, adenovirus-like particles, isometric, nonenveloped, containing icosahedral symmetry capsid, measuring 70-90 nm in diameter, were visualized. Reovirus-like particles, isometric, nonenveloped, spherical, characterized as "complete" or "empty", measuring between 65 and 70 nm in diameter, were also visualized in samples of the feces and small intestine. By the H & E, they were observed in the spleen numerous heterophiles, hypoplastic lymphoid follicles and hyperplastic red pulp. The lung presented hypertrophy and hyperplasia of the alveolar walls, alveoli with cellular debris and mucus; numerous heterophiles and monolymphocytic inflammatory cells. The liver had a marked macro and microgoticular steatosis, with a multifocal presence of nodules in the parenchyma. Monolymphocytic hepatitis and large nuclear basophilic inclusion bodies were also observed in hepatocytes, Kupffer cells and occasionally in endothelial cells. The large intestine presented monolymphocytic enteritis with hyperplasia of enteric lymph nodes and marked proliferation of eosinophils. Some areas showed flattened villi. The skin presented areas with hyperkeratosis, foci with balloonifrom degeneration and presence of eosinophilic inclusion corpuscles. In these areas a large number of eosinophils were observed. The kidneys presented monolymphocytic glomerulonephritis. The evaluation of the techniques employed allowed the rapid diagnosis of the viruses in the snakes.*

Keywords*— *Transmission electron microscopy, Histopathology, Snakes, Viruses.

I. INTRODUCTION

The breeding of captive snakes in Brazil has become an important activity, whose main segments of the market are directed to the commercialization of venom, export of non-poisonous snakes, slaughter of animals for sale of meat and leather and supply of snakes for specialized pet shops in pets animal (Tutzer, 2006).

Lampropeltis triangulum (false coral snake, also called milk snake), is one of the most widely distributed snakes in the Americas, occurring from southern Ontario and Quebec in Canada, to Colombia, Ecuador and Venezuela in South America. *Lampropeltis triangulum* is a mostly crepuscular or nocturnal and terrestrial snake that kills by constriction. Its diet consisting of a variety of prey items including insects, worms, spiders, birds, small snakes, frogs and small mammals (Aguilar-Lopes & Pineda, 2013). Because they are docile, non-venomous and easily manipulated, king snakes are kept in captivity, as pets (kingsnake Brazil, 2009). The milk snake is not listed by the IUCN (International Union for Conservation

of Nature), but in some areas, they may face significant pressure due to pet trade collection. Because of this species high value in the pet trade, many subspecies are now being bred in captivity for sale (Savitzky, 2004).

Reptilian paramyxoviruses belong to the *Paramixoviridae* family, genus *Ferlavirus*. They are negative sensed single stranded RNA viruses with a helical nucleocapsid packaged in a pleomorphic envelope (ICTV, 2016), and, among reptiles are found mainly in snakes of different families such as, Boidae, Elapidae, Colubridae, and Viperidae. Initially they were called ophidian paramyxovirus (OPMV) (Essbauer & Ahne, 2001), however, they were also isolated from lizards and tortoises (Marschang et al., 2009; Papp et al., 2010).

The genus *Ferlavirus* refers to a reptilian isolate, which consists of Fer-de-Lance virus (FDLV) found in the common lancehead snake (*Bothrops atrox*) (Clark et al., 1979).

Paramyxovirus is described as one of the major emerging agents that can threaten wildlife (Jacobson, 1993; Daszak et al., 2000) and is responsible for causing snake pneumonia (Marschang, 2011).

Clinical signs associated with acute and chronic OPMV infection range from anorexia, occasional regurgitation, acute dyspnea, acute inspiration, pneumonia, emaciation, mucosal diarrhea, muscle weakness, head tremor, putrid odor and / or neurological disorders. The animals may also die without presenting any of the symptoms mentioned. Studies of OPMV isolated from snakes and other animals have shown that these are endogenous reptilian viruses (Ahne et al., 1987; Homer et al., 1995; Richter et al., 1996; Marschang et al., 2002; Sand et al., 2004; Jacobson and Samuelson, 2007; Abbas et al., 2011; Papp et al., 2013).

Recently a fatal systemic necrotizing infection associated with a novel paramyxovirus in *Eunectes murinus* juveniles was described (Woo et al., 2014).

Adenoviruses that infect reptiles are members of the family *Adenoviridae*, genus *Atadenovirus*. Virions are non-enveloped, 70–90 nm in diameter. The icosahedral capsid consists of 240 non-vertex capsomers (hexons), 8–10 nm in diameter, and 12 vertex capsomers (penton bases), each with a fiber protruding from the virion surface giving the characteristic morphology. The genome is a single, linear molecule of dsDNA and contains an inverted terminal repetition (ITR) (ICTV, 2016). Reptilian adenoviruses have already been documented in about 12 reptile species. Unlike mammalian and avian adenoviruses, reptilians were not well characterized in their pathogenic potential and the ability to induce a primary disease. Diagnosis by isolating the virus in fresh tissue is not always reliable and therefore confirmation of reptilian adenovirus infection depends on diagnosis by electron microscopy for the identification of virus particles associated with histopathological changes, such as the presence of nuclear inclusion corpuscles. Adenovirus infections were diagnosed in different species of snakes and associated with liver, gastrointestinal, respiratory and central nervous system disease (Heldstab & Bestett, 1984; Jacobson et al., 1985; Schumacher et al, 1994; Perkins et al, 2001; Kim et al., 2002; Raymond et al., 2003).

Reptilian orthoreovirus belongs to the *Reoviridae* family, *Spinareoviridae* subfamily and *Orthoreovirus* genus (ICTV, 2016). Orthoreoviruses are non-enveloped viruses with an icosahedral capsid 70–80 nm in diameter (Attoui et al., 2011). The double-stranded RNA genome of orthoreoviruses consists of 10 segments grouped into three categories based on their electrophoretic mobility, three larges (L1-L3), three mediums (M1-M3), and four small segments (S1-S4 (ORF) (Day, 2009). They can induce cell-to-cell fusion. It has been demonstrated in several species of reptiles associated with sudden death, central nervous system disorders, skin lesions and pneumonia (Ahne et al., 1987; Marschang et al., 2002; Ducan et al., 2004, Ugurtas et al, 2008).

The knowledge of the viral infections that affect the king snakes, both kept in captivity as in free life, becomes important to elucidate many of the diseases that infect these animals, which may also constitute important zoonoses. Thus, this study aimed to report the simultaneous presence of paramyxoviruses, adenovirus and reovirus in snakes breeding, using transmission electron microscopy and histopathology techniques.

II. MATERIAL AND METHOD

2.1 Animals

In this study, 3 kingsnakes (*Lampropeltis triangulum* spp) were sent from a breeding in Rio de Janeiro, RJ, Brazil, in 2009. They presented a variable clinical picture with leukocytosis, cutaneous abscesses, loss of motor coordination, skin retention, epidermal vesicles, emesis, diarrhea, dyspnea and death. Feces and various organ fragments (lung, liver, spleen, pancreas,

stomach and small intestine) were processed by transmission electron microscopy (negative staining) and histopathology (H-E routine) techniques.

2.2 Transmission Electron Microscopy

2.2.1 Negative staining technique (rapid preparation)

In this technique, the samples of organ fragments and feces of 3 snakes were suspended in 0.1 M phosphate buffer at pH 7.0. Drops of the obtained suspensions were placed in contact with metallic copper grids, previously covered with a film of 5% collodium amyl acetate and stabilized with carbon. Next, the grids were drained with filter paper and negatively stained with 2% ammonium molybdate at pH 5.0 (Brenner and Horne, 1959; Hayat and Miller, 1990; Madeley, 1997). The grids were observed in a Philips EM 208 transmission electron microscope, at 80 kV.

2.3 Histopathology

2.3.1 Routine Histological technique (&H&E)

All the samples of organ fragments of 3 snakes (lung, liver, spleen, kidneys, large intestine and skin) were fixed in 10% buffered formalin, dehydrated, diaphanized and embedded in paraffin. 5 µm thick sections were stained with hematoxylin and eosin technique and observed under the direct light optical microscope.

III. RESULTS AND DISCUSSION

3.1 Transmission Electron Microscopy

3.1.1 Negative staining (rapid preparation)

Under the transmission electron microscope, a great number of paramyxovirus-like particles (fig.1), pleomorphic roughly spherical or filamentous, ranging in diameter from 100 to 500 nm, containing internal "herring-borne" nucleocapsid (fig.1, big arrow) with 12 nm in diameter and an outer envelope covered by spikes (minor arrow) were visualized in all the samples of the feces and fragments of organs examined. In samples of the small intestine, stomach, pancreas and spleen fragments, adenovirus-like particles (fig.2), isometric, nonenveloped, containing icosahedral symmetry capsid, measuring 70-90 nm in diameter, were visualized. Reovirus-like particles (fig.3), isometric, nonenveloped, spherical, characterized as "complete" (fig.3, big arrow) or "empty" (fig.3, minor arrow), measuring between 65 and 70 nm in diameter, were also visualized in samples of the feces and small intestine.

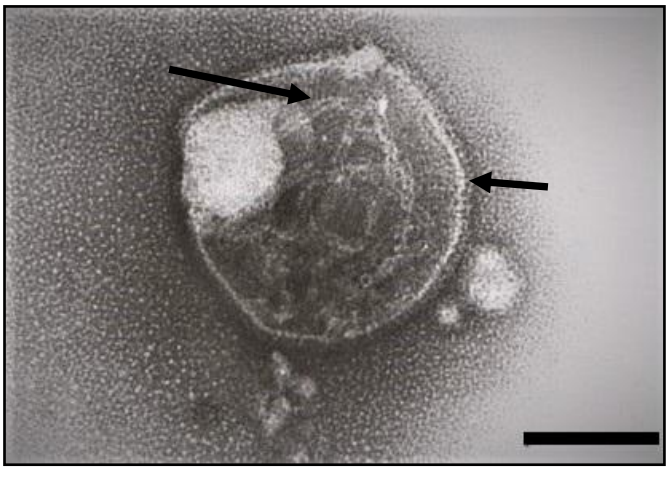

FIGURE 1: Negatively stained paramyxovirus particles, pleomorphic, roughly spherical, containing internal "herring-borne" nucleocapsid (big arrow) and an outer envelope covered by spikes (minor arrow). Bar: 120 nm.

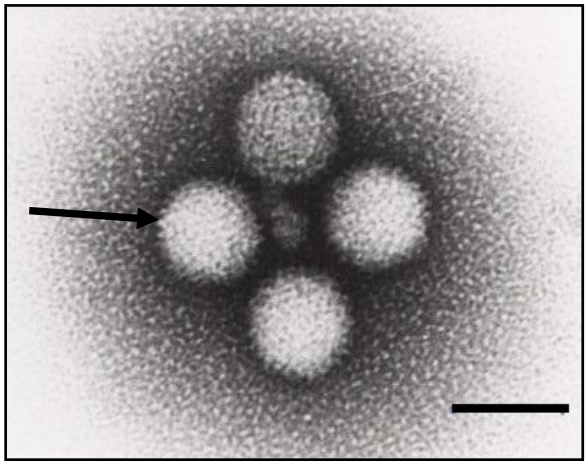

FIGURE 2: Negatively stained adenovirus particles, in small intestine suspension, showing a hexagonal shape with distinct closely packed capsomers (arrow). Bar: 80 nm.

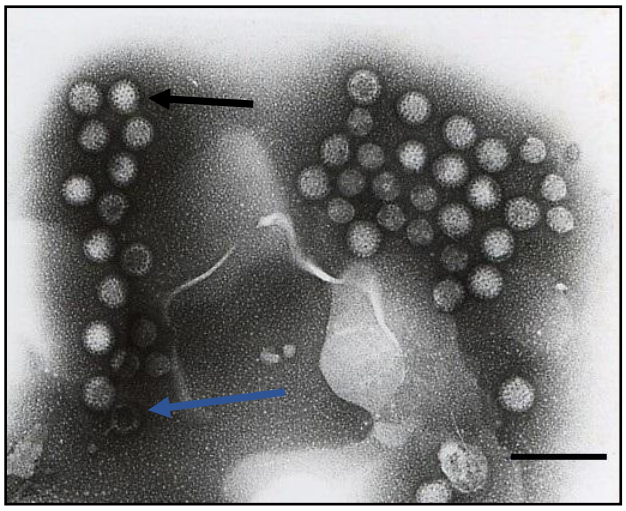

FIGURE 3: Negatively stained reovirus particles, in feces suspension by negative staining, showing "stain-penetrated" (black arrow) and "non-penetrated" (blue arrow) particles. Bar: 190 nm.

3.2 Histopathology

3.2.1 Routine Histological technique (H&E)

In the optic microscope we observed in the spleen numerous eosinophils, hypoplastic lymphoid follicles and hyperplastic red pulp (figs. 4,5). The lung presented hypertrophy and hyperplasia of the alveolar walls, alveoli with cellular debris and mucus; numerous eosinophils and monolymphocytic inflammatory cells (fig. 6). The liver had a marked macro and microgoticular steatosis, with a multifocal presence of nodules in the parenchyma. When enlarged, these nodules had a necrotic center surrounded by monolymphocytic cells, macrophages and innumerable eosinophils. The nodules were surrounded by connective tissue. Foci of monolymphocytic hepatitis and large nuclear basophilic inclusion bodies were also observed in hepatocytes, Kupffer cells and occasionally in endothelial cells. The capsule was thickened. Presence of granulomas (figs. 7-12). The large intestine presented monolymphocytic enteritis with hyperplasia of enteric lymph nodes and marked proliferation of eosinophils. Some areas showed flattened villi (fig. 13). The skin presented areas with hyperkeratosis, foci with balloniform degeneration and presence of eosinophilic inclusion corpuscles. In these areas (dermis and epidermis) a large number of eosinophils were observed (fig. 14). The kidneys presented monolymphocytic glomerulonephritis and melanomacrophages fig. 15).

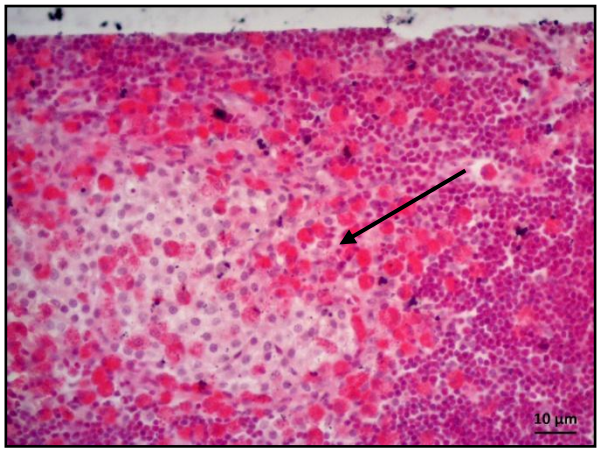

FIGURE 4: Photomicrograph of the spleen of snake. Observe numerous eosinophils (arrow), hypoplastic lymphoid follicles and hyperplastic red pulp. X400.

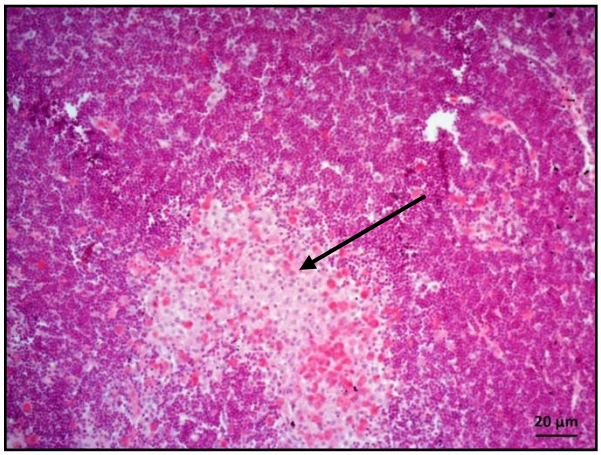

FIGURE 5: Photomicrograph of the spleen of snake. Observe lymphoid follicles (arrow). X200.

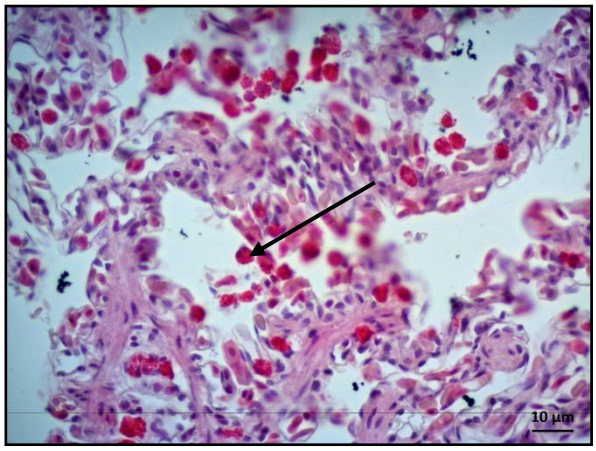

FIGURE 6: Photomicrograph of the lung of snake. Note numerous eosinophils (arrow).

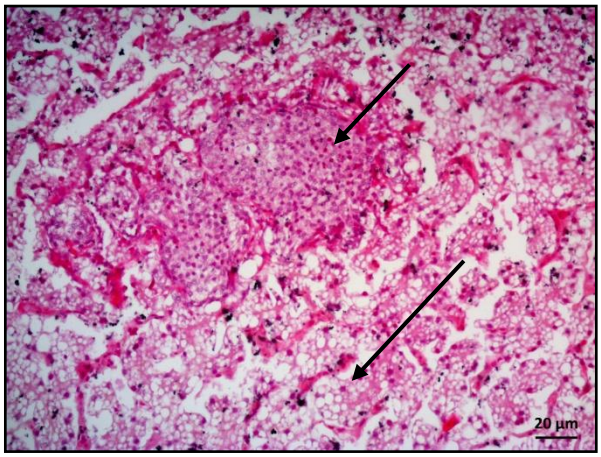

FIGURE 7: Photomicrograph of the liver of snake showing microgoticular steatosis (big arrow), with a multifocal presence of nodules in the parenchyma (minor arrow). X200.

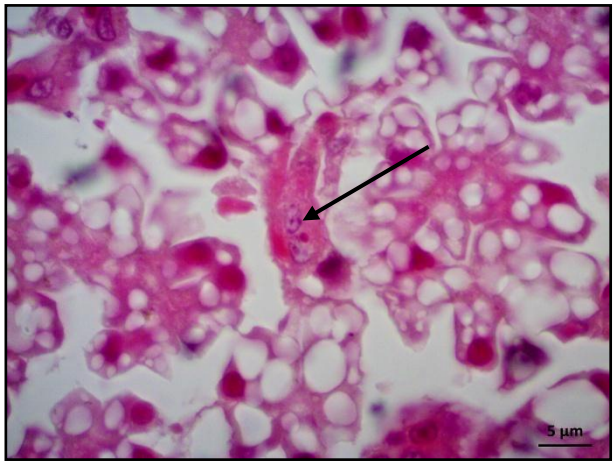

FIGURE 8: Photomicrograph of the liver of snake showing large nuclear basophilic inclusion bodies (arrow). X1000.

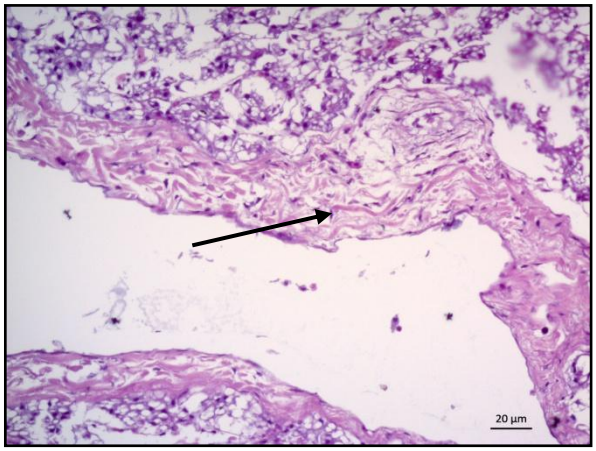

FIGURE 9: Photomicrograph of the liver of snake. Observe thickened capsule (arrow). X20.

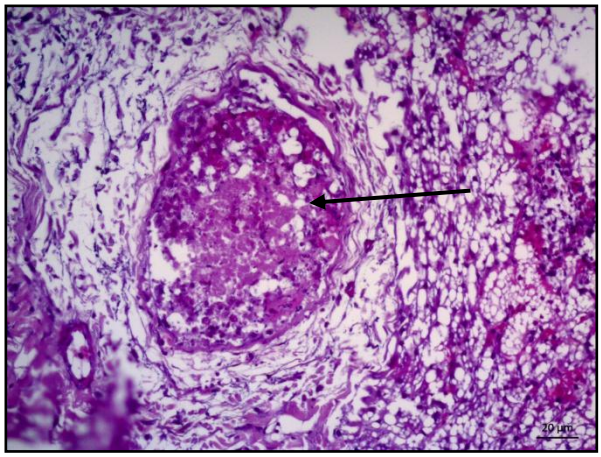

FIGURE 10: Photomicrograph of the liver of snake displaying granuloma (arrow). X20.

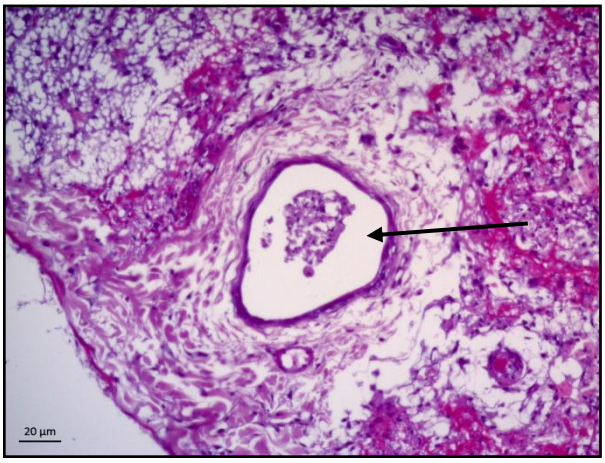

FIGURE 11: Photomicrograph of the liver of snake exhibiting granuloma (arrow). X20.

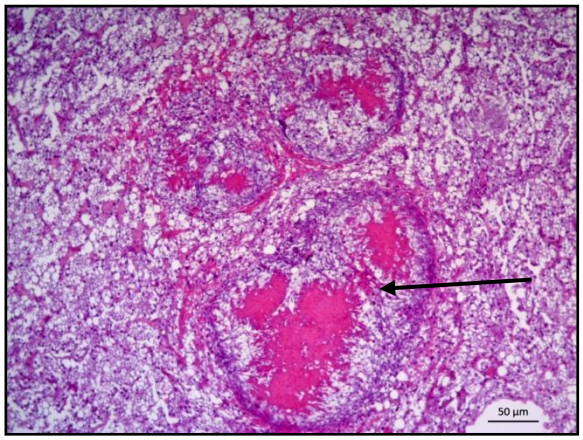

FIGURE 12: Photomicrograph of the liver of snake. Note presence of the nodules in the parenchyma (arrow) with a necrotic center surrounded by monolymphocytic cells, macrophages and innumerable eosinophils. X20.

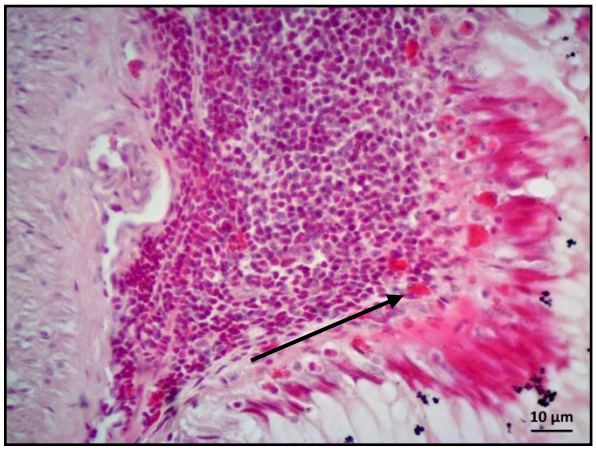

FIGURE 13: Photomicrograph of the small intestine of snake showing monolymphocytic enteritis with hyperplasia of enteric lymph nodes and marked proliferation of eosinophils (arrow). X400.

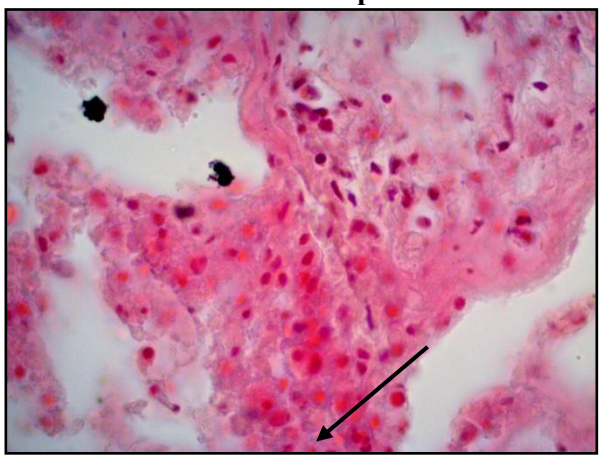

FIGURE 14: Photomicrograph of the skin of snake. Observe: balloniform degeneration and presence of eosinophilic inclusion corpuscles (arrow). X1000.

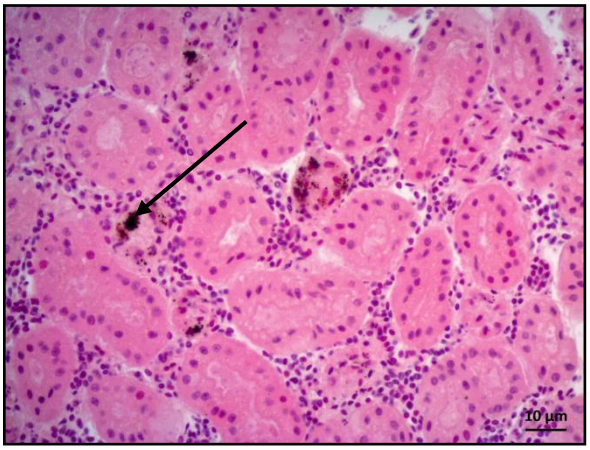

FIGURE 15: Photomicrograph of the kidney of snake showing monolymphocytic glomerulonephritis and melanomacrophages (arrow). X400.

In this study, organ and feces fragments of 3 king snakes (*Lampropeltis triangulum* spp) were examined by transmission electron microscopy and histopathology techniques.

Paramyxovirus particles were visualized in all fragments of organs, skin, faeces, lavage and lung mucus of all 3 snakes studied.

The variable clinical signs presented by the snakes, such as subcutaneous abscesses, skin retention, vomiting, mouth opening, wheezing, pneumonia, dyspnea, motor incoordination and leukocytosis, were also mentioned by other authors in several other species of snakes, infected by paramyxovirus, such as, *Bothrops atrox* (Clark et al., 1979), *Crotalus unicolor* (Jacobson et al., 1997), *Vipera xanthena xanthena* (Potgieter et al., 1987), *Phyton sp.* (Manvell et al., 2000), *Homalopsis buccata* (Papp et al., 2013), (Abbas et al., 2011; Starck et al., 2017), *Bothrops alternatus* (Kolesnikovas et al., 2011), *Bothrops jararaca* (Junqueira de Azevedo et al., 2011) in several species of snakes (Prpic et al., 2017) and in *Draecena guianensis* (Jacobson et al., 2001).

Histopathological examination showed the presence of interstitial multifocal pneumonia.

The main lesions caused by paramyxovirus in snakes are observed in the lungs, the main target organ and occasionally in the brain (Homer et al., 1995).

These findings were confirmed in other studies, in the species, *Crotalus terificus* (Homer et al., 1995), *Python regius* (Ucellini et al., 2014), *Crotalus unicolor* (Jacobson et al., 1997), *Homalopsis buccata* (Papp et al., 2013), *Pantherophis*

guttatus (Starck et al., 2017) and in several species of snakes (Jacobson et al., 1992).

Severe nephritis or necrotizing inflammation of multiple organs was related in *Eunectes murinus* (Woo et al., 2014).

Although proliferative pneumonia is highly suggestive of paramyxovirus infection, the definitive diagnosis requires additional tests such as isolation and viral identification or immunohistochemistry (Holmer et al., 1995).

The transmission electron microscopy examination revealed that the size and morphology of the typical paramyxovirus particles are similar of those other paramyxoviruses observed in other snakes species, as in *Eunectes murinus* (Woo et al., 2014), in *Bothrops atrox* (Lunger & Clark, 1979), *Crotalus durissus terrificus, Crotalus unicolor* and *Atheris* sp (Richter et al., 1996) in a lizard, *Draecena guianensis* (Jacobson et al., 2001) and in cell culture supernatant from isolates of various species (Ahne et al., 1999).

Adenovirus has been described causing severe diseases in reptiles. In birds and mammals adenovirus is mainly dependent on immunosuppression. In reptiles, however, adenovirus is not completely characterized by the fact that there are reports of infection without other recurrent diseases (Jacobson et al., 1992; Ogawa et al., 1992; Schumacher et al, 1999).

The major clinical signs reported in snakes and infected lizards, many of them also presented by the snakes of our study, were represented by vomiting and anorexia, also found in *Boa contrictor* and *Elaphe g. guttata* (Jacobson et al., 1985, Ramis et al., 2000; Mahapatra et al., 2013), pneumonia in *Elaphe guttata*, (Juhasz & Ahne, 1992), opisthotonus in *Pogona vitticeps* (Kim et al., 2002), stomatitis in *Elaphe quatuorlineata* (Heldstab & Bestetti, 1984), dermatitis in *Boa contrictor imperator* (Perkins et al., 2001), cycling in *Lampropeltis zonatta* (Raymond et al., 2003) and head tilt in *Boa constrictor* (Jacobson et al., 1985).

Histopathological diagnosis in the case of adenovirus infection is based on the presence of nuclear basophilic inclusion corpuscles in Kupffer cells and sinusoid endothelial cells, according to our findings. According to Marschang (2011) the most common histological change described in infected animals is hepatic necrosis. Eosinophilic intranuclear inclusion bodies were related in *Phyton regius* (Ogawa et al., 1992), in *Pogona vitticeps* (Wellehan et al., 2004), in *Elaphe g. Guttata* (Mahapatra et al., 2013), in *Boa constrictor* (Jacobson et al., 1985; Ramis et al., 2000; Perkins et al., 2001) in *Heloderma horridum* and *Heloderma suspectum* (Papp et al., 2009) and in *Lichanura trivirgata* (Schumacher et al., 1994).

We verified that the large intestine presented monolymphocyte enteritis with hyperplasia of enteric lymph nodes.

The presence of adenovirus was also associated with the cause of gastroenteritis in Chinese vipers (Jacobson, 1985).

In samples of the small intestine, stomach, pancreas and spleen, adenoviurs-like particles, isometric, nonenveloped, containing icosahedral symmetry capsid, measuring 70-90 nm in diameter, were visualized.

Due to the ease of visualization of viral particles within the clinical specimens, most of the studies on adenoviruses in reptilians have been realized utilizing transmission electron microscopy, both through the negative staining technique and the resin embedding technique followed by ultrafine sections. The morphological characteristics that we described were also described by other authors (Pénzes et al., 2014; Wellehan et al., 2004; Mahapatra et al., 2013; Juhasz & Ahne, 1992; Ahne & Juhasz, 1995; Jacobson et al., 1985; Ramis et al., 2000; Perkins e al., 2001; Papp et al., 2009; Raymond et al., 2003; Ogawa et al., 1992; Schmacher et al., 1994). Starck et al. (2017) utilized electron microscopy to study quantitative changes in the respiratory epithelial surface in the lung of infected snakes with paramyxovirus.

With reference to the reovirus, the significance of the infection caused by this viral agent in snakes is not completely elucidated.

The major clinical signs reported in reovirus infected reptiles have been, hepatic necrosis in *Opheodrys aestivus* (Landolfi et al., 2010), pneumonia in *Elaphe* sp (Lamirande et al., 1999), neurological signs in *Crotalus viridis* (Vieler et al., 1994) and dry lesions in *Lacerta viridis* (Raynaud & Adrian, 1976). The reovirus was also found in asymptomatic Chinese vipers (Blahak & Gobel, 1991).

The reovirus was experimentally inoculated into snakes species, producing pneumonia, indicating that reovirus can be a primary agent (Lamirande et al., 1999).

In birds, reovirus is a facultative pathogen that can trigger severe disease when associated with stress factors. This behavior can also occur among reptiles (Lamirande et al., 1999; O'Rourke & Lertpiriyapong, 2015). The presence of the reovirus was demonstrated in cutaneous lesions of lizards, corroborating with our findings in lesions of the king snakes of our study

(Ugurtas et al, 2008).

The clinical picture in a reptile with reoviral disease typically presents as pneumonia and neurologic signs, and is very similar to the clinical picture seen with paramyxovirus infection. The histologic lesions also resemble paramyxoviral disease (Wellehan et al., 2009).

Electron microscopy, however, allows a rapid and low cost diagnosis where viral particles can be easily visualized directly on specimens of tissue or faeces and has been used by many authors, associated with histopathology, PCR and cell culture or other techniques diagnosis (Latney & Wellehan, 2013). The negative staining technique also allows the detection of different viral particles in the same sample (Gentile & Gelderblom, 2014; Catroxo & Martins, 2015).

Typical reovirus particles were visualized in samples of the *Elaphe moellendorffi* and *Elaphe taenuris* (Lamirande et al., 1999), *Trimeresurus stejnegeri* (Jacobson, 1986), *Corallus Caninus*, *Elaphe longissima* and *Iguana iguana* (Blahak et al., 1995), *Phyton regius* (Ahne et al., 1987; Duncan et al., 2004), *Uromasty hardwickii* (Drury et al., 2002); *Opheodrys aestivus* (Landolfi et al., 2010), *Savannah monitor* (Jacobson et al., 1986) and in *Lacerta viridis* and *Varanus exanthematicus* (Ugurtas et al., 2008).

Simultaneous detection of the three types of viral agents (paramyxovirus, adenovirus and reovirus) in the three snakes of our study was also reported in three corn snakes (*Pantherophis guttatus*) by Abbas et al. (2011).

Concurrent infections with multiple infections agents, including multiple viruses, have been shown to occur and the interactions and effects of these concurrent infections are most yet understood (Marschang, 2011).

Coinfections with paramyxovirus and reovirus (Marschang et al., 2002) and with reovirus and adenovirus (Papp et al., 2009) have been documented in lizard. Simultaneous infection with herpesvirus and mycoplasma has been reported in tortoises (Salinas et al., 2011).

The occurrence of this co-infection is probably associated with the introduction of animals of uncertain origin to creation or inappropriate disinfection of the terrariums, after occurrence of diseased animals, consisting of source of infection to other animals (Abbas et al., 2011).

To prevent the introduction of infectious diseases into livestock, biosecurity measures such as correct disinfection of the environment, quarantine procedures, physical examinations of animals and rapid laboratory diagnostic tests should be instituted in the creation, avoiding losses of animals and losses economic (Prpic et al., 2017).

IV. CONCLUSION

Considering that viruses that affect reptiles are caused by emerging agents that can threaten wildlife, efficient techniques that provide rapid diagnosis are of paramount importance to assist in the immediate adoption of prophylactic and disease control measures, during outbreaks, avoiding important economic losses in the creations.

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Typology of Constraints and Recommended Solutions for the Agroforestry in the Cascades Region of Burkina Faso

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Abstract**—** *The tree-crop and / or animal association is a source of many ecological and socio-economic benefits, but it's facing various constraints. The main objective of this work is to identify constraints and solutions to improve the agroforestry level in the Cascades region. Specifically, it aims to identify the units of management; list the agroforestry techniques used; identify the levels and types of constraints and recommended solutions. Interviews were conducted with the supervisors of agroforestry activities from technical public offices, researchers, partners and producers from 10 villages selected according to their specificities. They focused on agroforestry practices, constraints and solutions in the management of tree-crop fields, riverbanks, nurseries, plantations and direct seedings with forest tree seeds. A typology of the constraints was made and consisted in listing them, classifying them in different types and levels. These results highlighted six kinds of units on which eight agroforestry practices were found; 41 constraints were listed, classified in three (03) levels then in 10 types. Finally, 14 solutions are recommended by the interviewed actors to remove these constraints. A synergy of actions between the actors will allow better development of agroforestry in this region.*

Keywords— Agroforestry, Parklands, Constraints, Solutions, Cascades Region.

I. INTRODUCTION

Agroforestry is the set of systems and techniques of soil development with trees and crops association and / or animals to obtain useful products or services for humans [1]. This association is simultaneous according to a spatial arrangement either or in a temporal succession. The three distinct components are the ligneous species, annual crops and animals. The animal component, although existing, is not always materialized, so in the case of the fallows the tree-crop association is sequential [2].

Thus, the agroforestry has a socioeconomic character with measurable benefits both ecologically and socially. Its practice must be developed in the production systems. The technological packages must be available for the farmers in order to improve their local knowledge's and popularize various practices. Agroforestry techniques require, to be adopted, a good knowledge of pedological, climatic, material and financial conditions and a commitment of the farmers. Agroforestry is developed in all climatic zones in Africa where the tree is integrated with crops to improve mainly crop performance and the ecosystem goods and services it provides [3; 4].

Since the 1950s, agroforestry researches have been conducted in the western Burkina Faso [5; 6; 7; 8]. However, this region has not benefited greatly the support of the projects and programs such as the northern, sahelian and southern regions of the country [9] [10] [11]. Many of the constraints that have been the subject of this study are hampering agroforestry practices in the western regions, particularly the Cascades region. The identification of these multiple constraints and the proposal of adequate solutions will allow a better practice of agroforestry. The present study has been initiated, taking into account this situation.

The global objective was to make the best understanding of the agroforestry practices and constraints. Specifically, it was (1) to identify management units; (2) list the techniques used; (3) identify the types and the primary, secondary tertiary levels of constraints to agroforestry development among the stakeholders; and (4) propose solutions to minimize or even remove these constraints.

II. MATERIAL AND METHODS

2.1 Site of the study

The site of the study was the Cascades region located in the extreme south-western of Burkina Faso. This area extends between 9 ° 25 and 10 ° 37 north latitude and between 3 ° 50 and 4 ° 46 west longitude. Ten villages sheltered the study: Diarbakoko, Duna, Kiribina, Kossara, Niarébama, Siniéna, Sitiéna, Tengrela, TiéTiékouna, Wolonkoto. These villages have

been the sites of previous agroforestry researches [12][13]. The climate of the region is Southern Sudanian [14] characterized by a wet season (April to November) and a dry season (November to March); temperatures ranging from 17 °C to 36 ° C and mean annual rainfall of 1000 mm to 1200 mm. In this region, we find different types of soils: battleship outcrops, vertisols on fluvial alluvium and hydromorphic soils. Between the two there are some little evolved non-climatic origin [15] [16]. The vegetation is dominated by all types of savannah including wooded savannah, trees, clear forest, and gallery forest and graminaen carpet in decline. The researches on the major floristic types of agroforestry parklands in Burkina Faso [17] showed that the Cascades region's parklands are dominated by *Borassusa keassii*, *Blighia sapida* and *Faidherbia albida* in the vicinity of human dwellings and by *Vitellaria paradoxa* and *Parkia biglobosa* in the bush fields.

2.2 Data collection

The information sought in this work focused on the use of agroforestry techniques; the constraints encountered and the solutions identified by the different actors. The data was collected from stakeholders in the four thematic groups (Table 1). The eight studied techniques are the Assisted Natural Regeneration (ANR), enrichment plantations, windbreaks, hedgerows, direct seedings, controlled clearings and animal parcages. About nurseries the three private nurseries of Siniéna, Diarabakoko and Tingrela were concerned. The preoccupations were their creation, their equipment, their functioning, and the plant's production-flow. For the technical services the information collected focused on the different agroforestry practices, the activities of the producers and the administration in the Cascades region, the constraints of implementation of each practice during the technical frameworks, the obstacles to agroforestry in general in the Cascades region. The constraints are listed on the questionnaires sheet in descending order of importance.

TABLE 1
THE VILLAGES SAMPLED ACCORDING TO THEIR SPECIFICITIES IN AGROFORESTRY

Specificities Villages	Tree-crop fields and Fallows	Riverbank Protection	Nurseries	Plantations-Direct seeding
Diarabakoko		X	X	X
Douna	X			
Kiribina	X			X
Kossara		X		
Niarebama		X		
Siniéna	X	X	X	
Sitiéna		X		X
Tiékouna	X	X		
Tingrela		X	X	
Wolonkoto	X			X

2.3 Data management

To assess the importance of agroforestry practices (p), a rating scale has been established [18]: 1) Low practice (1% ≤ p≤24%); 2) Unimportant practice (25% ≤p≤49%); 3) Moderately important practice (50% ≤p≤74%); 4) Important practice (75% ≤p≤100%). The percentages calculated represent the proportions of farmers who have adopted the concerned agroforestry practice.

A list of constraints has been established on the basis of the results of the interviews with all the stakeholders. A classification of the constraints was made in three groups according to the proportion of the producers (P) who identified them. They are tertiary when 1% ≤ P ≤25%; secondary when 26% ≤ P ≤50%. If 51% ≤ P ≤100% they are qualified as primary [19]. A second classification focused on the type of the constraint that can be natural, anthropogenic, social, etc.

Concerning the recommendations of the farmers and technicians, the actors to whom they were formulated are indicated. Indeed, a group of actors makes recommendations for both the group and their technical and financial partners.

III. RESULTS

3.1 The main management units and works carried out

The main management units encountered in the villages are the fields exploited continuously. These are fields of annual crops associated with ligneous trees which according to their location are house fields (CDC); village fields (CDV) and bush fields (CBD). In these units, producers perceive the positive and negative aspects of the tree-crop interactions. Another type

of management unit is the fallow where a period of rest of the soil is observed between two growing periods. Fallows are becoming scarce and their duration is shortened, about three to four consecutive years. To these are added the riverbanks and the courses or sylvopastoral zones. With regard to the riverbanks, the sensitization of users (farmers, breeders, fishermen) concerns 1) the maintenance and respect of a restriction area along the Comoé River which crosses the villages sites; 2) the use of pesticides; 3) the use of local utilitarian species introduced on the riverbanks. The frequencies of these activities depend on the financial supports available for the supervisors. In addition to the local utilitarian species planted on the riverbanks by the producers, other exotic species are planted there. They are *Eleais guineensis*, *Voacanga africana, Griffonia simplicifolia Carapa procera, Raphia sudanica*. The animal routes are distant from the river and have many herbaceous species and woody forage including *Borassusa keassii, Faidherbia albida, Diospyros mespiliformis*. By direct seeding, *Mucuna pruriens* and *Mucuna deeringiana* are associated with woody plants to enrich the rangelands and the soil of fallow. To meet the needs of local plants the private and community nurseries are installed in the villages.

3.2 The techniques used, their importance and links with the useful species of parks

There are eight most representative agroforestry practices at the study sites (Table 2). The Assisted Natural Regeneration (ANR) is a practice whereby peasants save, maintain and protect young volunteer agroforestry species from animals. The ANR concerns multipurpose species such as *Borassusa keassii, Vitellaria paradoxa, Parkia biglobosa, Mangifera indica, Sclerocarya birrea.* Enrichment planting is forest seedlings at the locations desired by the grower to meet a specific need. They are done in the fields to improve wood diversity. Live hedges are dense plantations and aligned with trees (about 1.50 m high) whose many branches obstruct men and animal routes. In the study villages windbreaks are found and their role is to protect the crops against the harmful effects of the winds. The farmers learned how to make hedgerows and windbreaks for wood production, non-timber forest products and the provision of ecological services. They are essentially made of *Acacia nilotica, Gmelinaarborea, Senna siamea. Jatropha curcas* was also introduced into hedgerows (Figure 1). Direct seeding of forest seeds is particularly relevant to *Borassusa keassii* and other local species such as *Parkia biglobosa, Faidherbia albida.* Their seeds require pre-treatment with sulfuric acid. Most of the projects that have occurred in the region have been forest seed distribution and subsidy channels from the National Forest Seed Center (CNSF) either for seedlings produced in nurseries or for direct seeding. Controlled land clearing is a practice in which farmers choose and save both mature and young trees in the fields. Animal parcage represent the association of the three crop-tree-animal components of an agroforestry system. In the dry season, the animals kept in a pen, retreat under the trees defecates, creating ranges of soil fertility heterogeneity.

TABLE 2
THE MOST REPRESENTATIVE AGROFORESTRY PRACTICES IDENTIFIED ON THE MANAGEMENT UNITS

Management units Agroforestry practices	CDC	CDV	CDB	Improved fallows	Riverbanks	Animal routes	Total
ANR	3	3	4	3	2	3	18/24
Plantations of enrichment	2	3	3	3	3	1	15/24
Windbreak	1	2	3	3	3	2	14/24
Live fences	1	2	3	2	4	2	14/24
Direct seeding	2	3	2	1	2	3	13/24
Thorny fences/dead fence	2	1	2	1	3	1	10/24
Controlled clearings	1	1	3	2	1	1	09/24
Animal parcages	0	1	2	1	0	2	06/24

75%≤p≤100% : Importante practice, p= 4; 50%≤p≤74% Practice moderately important, p= 3 ; 49%≤p≤25% : Pratique peu importante, p= 2; 24%≤p≤1% : Low pratique, p= 1 ;p=0 for inexistente practice in the management unit.

The table 2 presents the eight practices and their importance in the management units. It appears that ANR are important in tree-crop fields, fallows and rangelands. Enrichment plantings are moderately important in CDV, CDB, improved fallows and on riverbanks. Live hedges and windbreaks are mostly practiced in the CDB and on the riverbanks. Direct seeding is not commonly done; however, it is moderately important in the CDV and the rangelands. Except for the riverbanks, dead hedges are sparsely distributed. They are present in CDC managed by women, especially on the riverbanks for the protection of vegetable crops. Controlled clearing land is more prevalent in CBD, while animal parcages are practiced with low importance on CBD and rangelands.

Figure 1: Live fences of *Jatrophacurcas* around the ligneous nurseries of Tengrela, Comoé

3.3 Typology of constraints to the practice of agroforestry

***Constraints*:** A total of 41 constraints were listed and their proportions evaluated (Figure 2). The most important ones experienced by more than 80% of the producers are the lack of water, the land problems, the financial insufficiency for the regular execution of the activities and the lack of follow-up by the technical services. The interviews revealed that the populations of the villages of Tingrela, Nekanklou, Tiékouna and Sitiéna refuse the establishment of multipurpose woody species plantations proposed by the MCA-BF for the riverbanks protection. This reluctance emanates from the village of Tingrela where it is known that the increase of the human population makes it necessary to exploit the fertile lands of the riverbanks. The problems with the Comoé River, Lake Tingrela and the rivers of the village sites are summarized in their anarchic exploitation: the silting of the river which results in floods and early drying up; the almost total absence of plant formations; the use of chemicals in market gardening and gold panning for the ores washing. These products are harmful to human and animal health. Some consequences linked to the bad use of pesticides are the drying up or even the death of the plants (figure 3) and especially the fish of the Silurus genus dominating in the water reservoirs. Four pesticides are commonly used on the riverbanks: Emacot 019 (Emamectin benzoate 19 g / l), Lambdacal P 315 EC (Lambdacyhalothrin 15 g / l), Decis 10.75 EC (Deltamethrin 25 g / l) and Cypercal P 330 EC (Cypermethrin 30 g / l). Another constraint revealed is that during the plowings, woody regenerations are desiccated except those already identified and spared by the producers. To this constraint is added the grazing and trampling of the regrowths by the wandering animals despite the surveillance of the producers and the obligation made to the pastors to borrow the cattle tracks identified. There is also the destruction caused to plantations by elephants and hippopotamuses which are particularly important in the villages, especially in Diarabakoko, Niarébama, Tingrela. In the Cascades region, the practice of agroforestry faces land issues related to customary and modern rights. There is also a lack of manpower in the area due to field work and socio-economic activities. These last activities, although temporary, are consuming young work force. It was found that the lack of good quality of forest seeds is a constraint with a aggravating factor that is the collection of immature fruits of ligneous trees such as *Parkia biglobosa*, *Vitellaria paradoxa*, *Sclerocarya birrea*. For financial interests, women make premature picking of fruits; ripen them early by using carbide in order to sell them. Finally, parasitic attacks (*Plodia interpunctella*, *Acantho slides obtectus*) have a negative influence on the quantity and quality of the seeds of these fruit trees.

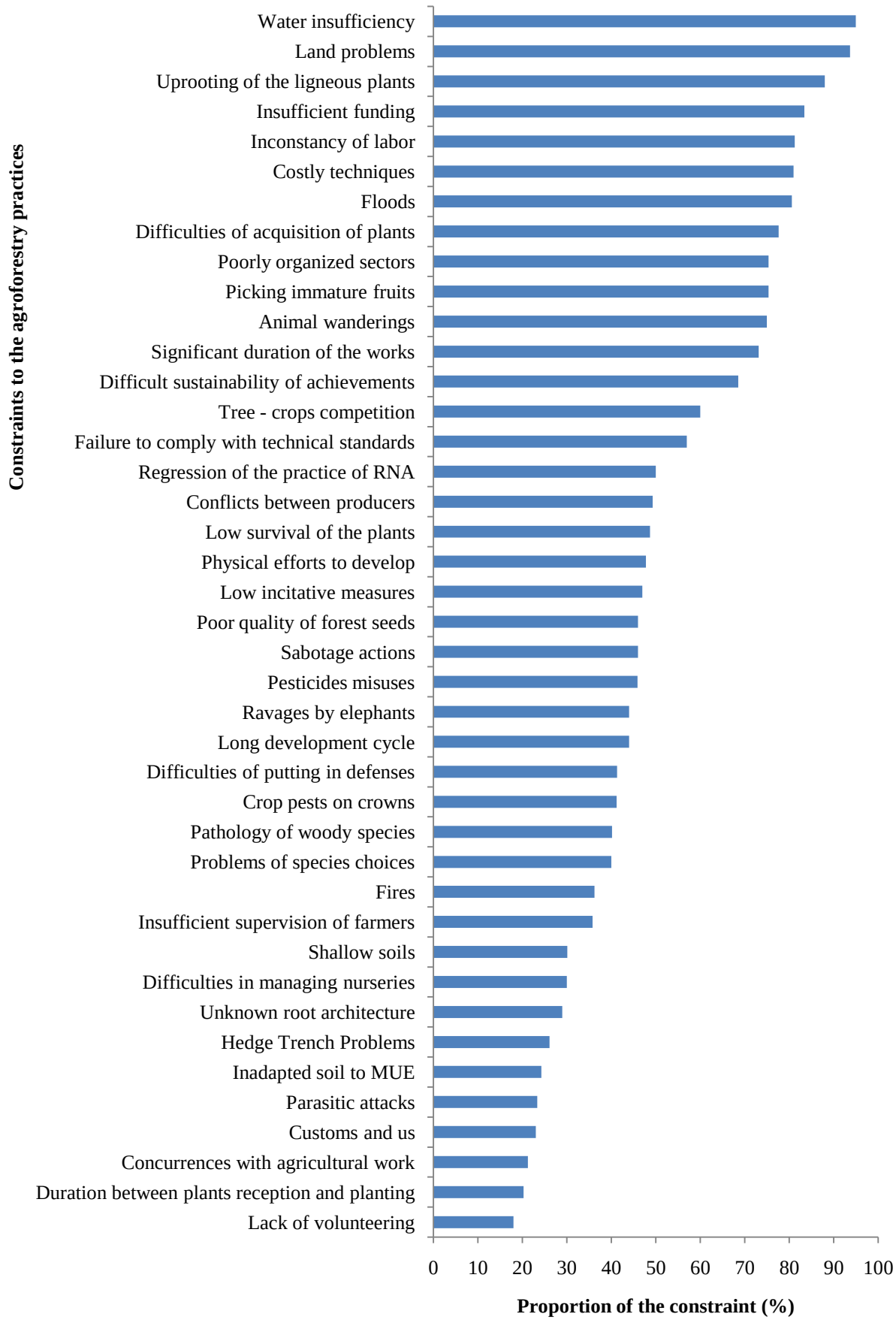

Figure 2: The different constraints enumerated by the agroforestry practicers

TABLE 3
THE TEN TYPES OF CONSTRAINTS IDENTIFIED

N^0	Type of the Constraint	Constraint
01	Technical	Picking immature fruits
		Significant duration of the activities
		Duration between plants granting and plantation
		Problem of trenches of live fences
		Insufficiency of supervision
		Misuse of pesticides
		Poor quality of forest seeds
		Low survival of plants
		Regression of RNA practices
		Non compliance with standards
		Ligneous uprooting
02	Anthropogenical	The fires
		The elephant ravages
		Animal wandering
03	Biological	Unknown root architecture
		Long cycle of development
		Tree-crop competition
04	Social	Competition with agricultural works
		Inconstancy of the workforce
		Lack of volonteering
		Costums and us
		Difficulties of nurseries management
		Problem on species choices
		Difficulties of defens
		Sabotage actions
		Conflicts between farmers
		Sectors poorly organized
		Land problems
05	Climatic	The flows
		Water insuffisance
06	Financial	Difficulties to get plants
		Cotums and us
		Insuffisancy of financial supports
07	Mécanical	Physical effort to develop
08	Natural	Crop pest on the crowns
		Parasitic attacks
		Ligneous pathology
09	Pedological	Inadapted soils to MUS
		Shallow soils
10	Strategical	Low incentives dispositions
		Difficulties to sustain gains

Figure 3: The drying of *E. guineensis* caused by the pesticides on the riverbank of Siniena

The levels of the constraints: The results indicate 39.02% of primary constraints, 46.34% of secondary constraints and 14.64% of tertiary constraints. Referring also to Figure 4, the lack of water, the land problems, the difficulties of seedlings acquisition, the insufficiency of funds for the execution of the works, the application of the techniques according to the required standards are now the main constraints for the development of agroforestry in the Cascades Region. It means that these constraints have been recognized by more than 50% of respondents as major constraints. The riverbanks are exploited to minimize water and soil fertility problems. The law 034 on land ownership is not rigorously applied. It is the traditional land tenure system that largely prevails in land management. Local agreements consist of negotiating land with customary authorities and Village Development Committees (CVD):. These agreements are not valid acts from the point of view of the law. These Committees are involved in the management of the land but land chiefs ensure the granting or the loan of plots of exploitation. The inheritances of plots are from father to son; Loans require both the agreement of the owner and the chief of land often materialized by ritual sacrifices. Land tenure, dominated by short, medium or long-term loans, does not promote agroforestry. There is an implied prohibition on the loan recipient trees except *Borassus akeassii*. In addition, the latter undertakes to release the parcel as soon as the owner or his descendants need it.

The constraints of lesser incidence include parasitic attacks, habits and customs, the lack of voluntary spirit among producers for work trials and time management difficulties during the field work when it is reduced on annual crops. Indeed the customary requirements in the management of the plots borrowed or the reluctance of some producers for the introduction of new agroforestry species such as the *Vocacanga africana* are constraints. The highest proportion of constraints is secondary (46.34%).

The types of constraints: Ten types of constraints have been specifically distinguished as well as the impacts that can result (Figure 4), among which are recognized anthropic, biological, climatic, financial, mechanical, natural, pedological, social, strategic and technical constraints . As shown in Figure 4, each constraint type has two or three of the primary, secondary, or tertiary levels, except for the biological, mechanical, and pedological types that are characterized by a single level. The soils of the Cascades region are agronomically more suitable than those of several other localities. Their handicaps for agroforestry are perceived as tertiary constraints.

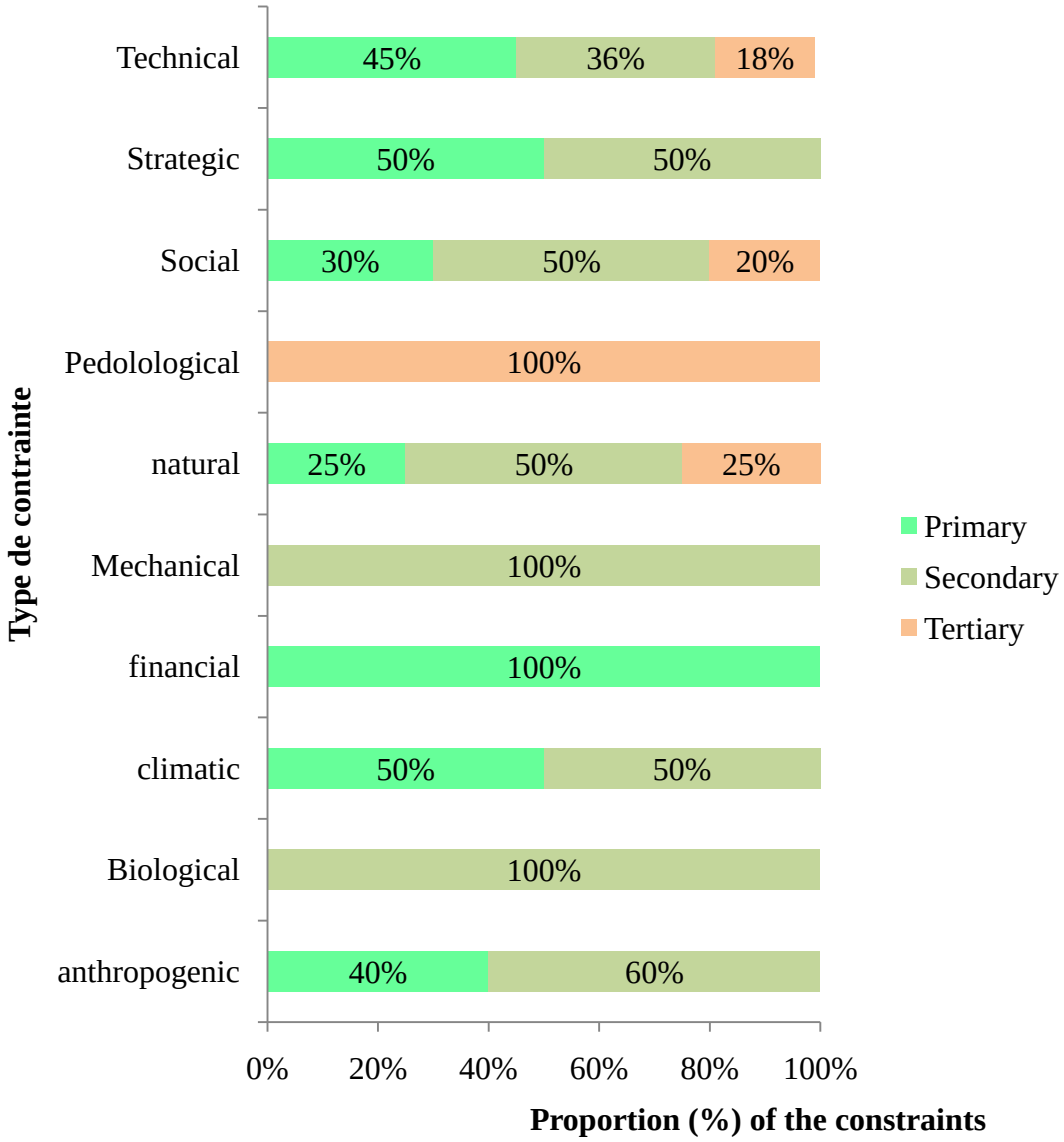

Figure 4: Proportions (%) of the constraint level staking into account the identified types

3.4 The recommended solutions to improve the practice of agroforestry

The search for solutions and suggestions with the producers, the technical partners, the Forestry officers responsible for carrying out the work related to the different aspects of agroforestry led to the results presented in Table 4. It appears that these solutions, recommendations and suggestions made by the interviewees are addressed to the four types of actors involved in agroforestry: the producers, the technicians of the Regional Directorate in charge of the Environment and their partners, the researchers and the decision-makers. Two solutions concern all the actors whereas those which address simultaneously to three types of actors are five in number: the recommended solutions for the valorization of the techniques WASC-DRS and the forage species engage the producers, the technicians and the researchers of the domain. Those relating to practical training, the synergy of actions between specialists and the promotion of agroforestry techniques through the execution of projects and programs are the responsibility of technicians, researchers and decision-makers. The other solutions concern different combinations of two types of actors. They aim mainly to improve the practice of the ANR, the reduction of the farmer-pastoral conflicts, the land security, the use of the pesticides, the awareness against the bad practice of the fires, the management of the densities of the trees in the fields and revision of the list of protected species. The misuse of pesticides is known to be dangerous for humans, animals, plants and natural resources in general. Forest officers educate producers in this area. These are important targets for capacity building for the use of these chemical products. Recommendations for training extend to all technical services (public, NGOs) and researchers.

TABLE 4
THE PRECONISED SOLUTIONS AND SUGGESTIONS TO THE DIFFERENT GROUPS OF ACTORS

N⁰	SOLUTIONS-SUGGESTIONS	FARMERS	TECHNICAL OFFICES	SCIENTIFIQUE RESEARCH	DECISION MAKERS
01	Train the farmers to the techniques of pushing back the elephants				
02	Take reoressive actions against the collectors of pods and immature fruits				
03	Revalorize WASC/DRS techniques to limit water problems				
04	Valorize the fodder ligneous to reduce the conflicts farmers-breeders				
05	Practice ANR to reduce the plantation constraints				
06	Set up exchanging frameworks between farmers and breeders				
07	Precede the trainings by the practices				
08	Establish a synergy of actions between environmental, livestock and agricultural ffices				
09	Demand the promotion of the agroforestry techniques in the ESMP of the projects				
10	Go on sensitizing the different actors on the law 034 related to land tenure				
11	Strengthen the capacity of the farers in the pesticide uses				
12	Sensitize the people against the bad practices of fires				
13	Continue the works on the densities of the ligneous species to keep on field				
14	Review the list of the protected species				

Colored parts = Concerned actors; WASC/DRS = Water and Soil Conservation/Defense and Restoration of Soil; ANR=Assisted Natural Regeneration; ESMP= Environmental and Social Management Plan

IV. DISCUSSION

A variety of agroforestry practices on various land use systems exist in the agrarian landscapes of the Cascades region. This work reveals that agroforestry is also developed in the Western and South-Western regions, which are among the most watered and fertile lands of Burkina Faso. The importance of agroforestry is well appreciated by farmers in this region who, according to earlier works, recognized that the tree in the field increases soil moisture, lowers soil temperature, slows down soil loss through erosion and improves crop yields [6]. It is therefore a science for both arid, semi-arid and humid areas [20]. While agroforestry is practiced in all areas, it should be noted that it is not universal in its logical conception. Indeed the association of crops with trees differs widely according to the place. Formerly practiced on a large scale to meet the needs of soil fertility, fallow is no longer relevant for most farmers faced with insufficient arable land and when the use of fertilizers and pesticides seems to be an alternative. Climatic conditions, soil conditions, socio-economic and cultural conditions are all factors that make agroforestry unique in an environment site [6]. The techniques and floristic composition are closely related to the services and goods provided by the tree component of the system [21] [19]. The main park species are *Borassusa keassii, Mangifera indica, Parkia biglobosa, Vitellaria paradoxa, Faidherbia albida* and *Anacardium occidentale* [6].The choice of species obeys the rule of the producer interests through the goods and services that result. The application of the eight techniques described evokes multiple obstacles, but in the first place the constraints inherent in agroforestry as a whole are legion. Their typology in the Cascades region, as shown in Table 3 and Figure 7, highlights a variety of major, secondary and tertiary constraints. Each type of constraint has one or more levels. Primary-level land issues are common in many parts of Africa and Burkina Faso, as in the Cascades region. In the face of customary conceptions, many difficulties prevent the application of land tenure rules and legal rights related to land and trees. These difficulties often hinder the realization of the potential ecological and socio-economical benefits of agroforestry in many areas [3]. In addition to the climatic problems that result in water shortages, land issues are the most important to deal with in the Cascades region. Faced with the refusal to

evacuate populations (whose fields are located on the easement strips) with regard to riverbank development, and to give large portions of land to women to take gender into account, many projects and programs have failed. Women have very few rights to set up agroforestry parklands as they are the main users of wood and non-timber forest products [21]. The foundation of all work related to agroforestry is the availability of seeds and seedlings for the implementation of different agroforestry techniques. The technical problems related to seed management, the lack of financial support for production costs, the differences between the plant granting and the planting are factors that limit the availability of seedlings. Similarly, failures in the organization of agroforestry sector actors in the management of private, village or communal nurseries, reinforced by the inconsistency of the customer, hamper the production of nursery plants and their flows [22].

The animal wandering is also a serious handicap to the development of agroforestry techniques both in the Cascades region and throughout the country, as evidenced by the constraints listed in several localities. In fact, the major pressures on plantation and RNA seedlings stem from trampling and grazing by animals on the banks of several wetlands [8] are perceptible through the plantations of *Eleais guineensis, Carapa procera, Bambusa vulgaris, Raphia sudanica* but some efforts remain to be made, including the respect of the band of servitude of 100m wide on both sides of the river. Among the constraints, we found the inconstancy of the workforce for the reason that it is an industrial, commercial and tourist zone. It is recognized that in the city and the surrounding villages, the workforce is scarce and expensive during the periods of temporary employment offered by industrial and tourist activities. From the production of sugarcane over large areas to industrial production and the harvesting of raw materials, juvenile labor is absorbed. The numerous secondary constraints are mainly technical, anthropic, natural and biological types. The poor survival of seedlings and the misuse of pesticides result from the lack of technical supervision, which is also a consequence of the lack of financial resources in the technical services to ensure regular monitoring of field work. The work of the Regional Direction in charge of the Environment of the Cascades region in collaboration with the MCA-BF and the Woul Association illustrates the weakness of the survival rates, variable from a species to another: *Eleais guineensis* (61 , 48%), *Carapa procera* (13.92%), *Bambusa vulgaris* (6.78%), *Raphia sudanica* (10.97%) [7]. To increase the survival rate of all species, it is imperative to take steps against the mismanagement of seeds, the effects of long periods of flooding on these sites, the misuse of pesticides and the animal grazing. This means that the focus should be on the work and provisions that contribute to maintaining the viability and quality of tree seed, the desensitization of river beds, the protection of the riverbanks from erosion, replenishment of gallery forests, protection of flood areas, awareness of pesticide use, respect for grazing areas and animal corridors. Moreover, concerning the lack or insufficiency of financial resources, it is notable both for producers and technicians. In the Cascades region, the major obstacles to the development of agroforestry are anthropic, social and natural. They are accentuated by ignorance and / or rejection of good practices by some traditional leaders. Flooding, the collection of immature seeds, the ravages of elephants, the lack of volunteer spirit for testing work are also considerable constraints. Technical supervision schedules experience regular lags due to flooding [21]. Thus, on the basis of the results we obtained and although the constraints seem specific for each climate zone, we agree with some authors [18] that the limits to the development of agroforestry are at the level of four types of resources: material, land, human, financial and informational.

While natural barriers such as floods remain difficult to overcome, those of a socio-cultural and administrative nature require more commitment from rural populations, technicians and financial managers. So far investments are concentrated in the Sahel, northern and arid regions of Burkina Faso [23] [24] recognized as being highly vulnerable to soil degradation factors and to host the priority actions. However, the wetter areas should be better taken into account in order to sustain the assets already accumulated and thus develop more agroforestry.

V. CONCLUSION

Based on the present work and referring to the constraints identified by various works on agroforestry in Burkina Faso, the recommended solutions to strengthen agroforestry in the Cascades Region should aim first and foremost to resolve land issues by sensitizing the various stakeholders on Law 034. This law guarantees the land security without which sustainable actions cannot be developed in an agroforestry system. It provides legal provisions including the certificate of land ownership. There is a compelling need for technical services in general and forest services in particular to be provided with financial, material and logistical resources to ensure effective management of their activities, as awareness, capacity building and technical capacities are their responsibility.

For financial partners, projects and programs, a broader vision of the areas of activity should be considered. Consensus should be constantly sought between producers and technical services in the choice of activities to be carried out. Since the success of the Research-Development projects and programs depends on producer buy-in, the consensus sought for the

promotion of plant species and technologies is an asset to take into account farmers' desiderates. It is important to take into account all the climatic zones of the country so that agroforestry will fully play its role of prevention and remedy to the problems of agrosylvopastoral productions.

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Effect of Operation Variables of Potato Digger with Double Chain Conveyors on Crop Handling and Machine Performance

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Abstract— *The experiments were conducted at Al- Gimma Agricultural Scheme in the Tragma area- Shendi locality, River Nile State during April – 2017, to study the effect of some operational factors related to harvesting machine such as tractor forward speed (4.4, 5.6 and 6.7km/hr, harvesting depth (16, 18 and 21cm) and the conveyer inclination (15° and 20°) on some of potato crop handling such as lifting potatoes, cut of potatoes, Bruised and Total bruised (Damage) index potato and some of machine performance such as travel reduction (wheel slippage), effective field capacity and fuel consumption. The results showed that, there were significant influences of forward speed, harvesting depth and conveyer inclination on tubers lifting, cut of potatoes while the effect of different forward speed showed no significant effect on potatoes damage, further no significant on the percentage of scuffed damage tubers, peeler damage tubers, severe damage tubers, total damage index as effecting by conveyer inclination. As the digging depth of digger increased from 16 to 18, the lifting potatoes increased from* 93.42 *to* 94.42*%, while decreased from* 94.42*% to 87.72% when the digging depth decreased from 21cm to 18cm. Significant and consistent increase in tubers lifting percentage was recorded due to increase in conveyer inclination. Less percentage of scuffed, peeler, severe damage tubers and total damage index of 0.2%, 0.0%, 1.6% and 21.9, respectively were recorded at speed of 6.7km/hr, while the highest percentage of scuffed, peeler and severe damage tubers of 2.1%, 0.3% and 2.7% respectively were recorded at Speed of 4.3km/hr.*

Statistical analysis (P<0.05) showed that increasing the forward speed, increased effective field capacity and fuel consumption significantly while there was no significance effect on wheel slippage. Furthermore, increasing the digging depth increased the wheel slippage and fuel consumption significantly where the effective field capacity significantly decreased. The conveyer inclination showed no significant effect on machine performance.

Keywords— potato digger machine, lifting potatoes, cut of potatoes, bruised potato, and Total Damage index and machine performance.

I. INTRODUCTION

The tropical root and tuber crops are comprised of crops covering several genera. They are staple foods in many parts of the tropics, being the source of most of the daily carbohydrate intake for large populations. These carbohydrates are mostly starches found in storage organs, which may be enlarged roots, corms, rhizomes, or tubers. Many root and tuber crops are grown as traditional foods or are adapted to unique ecosystems and are of little importance to world food production. Others such as cassava (ManihotesculentaCrantz) and white-fleshed sweet potato (Ipomoea batatas L.) are known worldwide. [1].

The potato (Solanum tuberosum L.), Solanaceae, is the most important oleracea culture around the world. It is considered the fourth largest source of human food, standing after rice, wheat and corn. The global annual production of potato is around 321 million tons, being cultivated in about 125 countries. More than a billion people eat potatoes every day around the world [2]; [3].

Potato is one of the main human alimentary resources. It was the sixth alimentary product in the world after sugar cane, maze, rice and paddy, wheat and milk [4]. Among the processes that make up the production system of potato cultivation, harvesting is presented as a crucial step, and one of the most expensive in the production process [5]. In Sudan There are problems regarding potato cultivation and storage. The collection of these problems cause the cut of product yield and rise of wastage value as the mean of potato production is 24 tons/ha but this number amounts to 50 tons/ha at developed countries [6].

Potato wastage values during the investigation were 48% from harvest stage to consumption and wastages of harvest implements were declared 1.72% [7]. Mechanical harvest of potato relative to manual harvest causes 65% frugality at harvest time and 45% at harvest costs [8].

These statistics show importance of activities in the field of potato diggers. [9] Made a potato digger and evaluated it. Mean of hurt potato tubers by set was stated 3.2%. [10] Designed a one row mounted potato digger that the hurts of harvested potatoes were reported 4% and up to skin. [11] Studied a potato digger with oscillating blade. Generated clods with lower mean of geometric diameter were reported and volumetric density was decreased.

[12] Designed and tested a two row mounted potato digger and reported that potato bruises were increased with addition of frequency and amplitude of vibration but it had not much effect on the remained potatoes in soil. In addition, amplitude had not much effect on traction but with increase of frequency traction was diminished

In Sudan, harvesting is usually performed manually or semi-mechanized, and share responsibility for the high cost of production. In the semi-mechanized harvesting, diggers are used, coupled to a tractor, which degrade the furrows and expose the tubers. Later, the collection is done manually by men or young women who also carry out a preliminary field selection. However, self-propelled harvesters have been used in advanced countries for potato culture. The trend toward mechanization of the total harvest is related to the availability and cost of manpower. These harvesters chop the ridges apart and collect the potatoes, in two or more rows, directing them to the carrier trucks. They are larger machines, which require elongated rows to avoid maneuvers and frequent loss of time [13], which reduce the operational capability of the machine.

According to [14], the process of mechanized harvesting of potatoes can represent a great advance for the producing regions, mainly to optimize the production process, with increased production area, faster removal of tubers from the ground when free risk of attack from pests and diseases, and stronger compliance with delivery dates of production. However, the decision to invest invariably involves risks, which must be provided when one decide to invest in certain equipment. The acquisition of harvesters involves high investment, and is only justified if there is a significant effect on the profitability of the activity [15]. The selection of an agricultural machine can become a daunting task, because there are many variables to consider, and choose the most appropriate equipment to a farm is one of the most important stages of the production process [16].

Cultivation in a large area will involve labour intensive work especially during the harvesting operation. Currently, sweet potato is mostly harvested manually. The manual labour cost for a harvesting operation constitutes about 30 - 40% of the total operational cost [17]. In manual harvesting of sweet potato tubers, the farmers have to cut and pull out the vines and lay them along the furrow. The tubers will then be dug by using a hand tool such as a hoe and fork, followed by manual collection. The tubers are transported in a basket or gunny sack. The most strenuous and back-breaking task is digging the tubers. The harvesting operation of sweet potato requires about 150 man-hours per hectare [18]; [17].

The potato harvesters specialized in supplying the potato industry began a movement for the acquisition and exchange of experiences with imported potato harvesters, and this created, consequently, a demand for information relating to real opportunities for the improvement that the harvest mechanization has facilitated [14]. With the advent of new technologies, studies are needed to quantify the real operational capability and costs of these new harvesters, as well as any loss of tubers during harvest, given the low availability of such data and the recent entry of self-propelled harvesters.

Keeping in view all the above salient criteria, the main objective of the present research work is to study the effect of some operational factors related to harvesting machine such as tractor forward speed, harvesting depth and the conveyer inclination on some of potato crop handling such as lifting, cut of potatoes, Bruised and Total bruised (Damage) index potato and some of machine performance such as travel reduction (wheel slippage), effective field capacity and fuel consumption.

II. MATERIAL AND METHODS

2.1 Experimental site

The experiments were conducted during April - 2017 in a commercial potato crop grown in the area under the center pivot system, in Al- Gimma Agricultural Scheme owned by GIAD Industrial Group, in the Tragma area- Shendi locality, River Nile State (North of Sudan). The variety that grown was Belini, spaced 18 cm between plants and distance between rows was 90 cm depth of 7 cm. The crop was planted on 24-29/12/2016 and the harvesting began on 10/4/2017. The Engineering characteristics of the examined soil are given in Table 1; the predominant soil type is sandy clay loam soil.

2.2 Experimental design and treatments applications:

In this study, a factorial experiment was (arranged in a split – split plot design with three replicate for each, the three lifting depths (16, 18, 21cm) were assigned to the main plots while the three forward speeds (4.4, 5.6 and 6.7 km/hr) and two conveyer inclination degree (15° and 15°) were distributed to the sub-plot and sub-sub-plots respectively, giving a total of 54 plots. The treatments were randomly distributed in the main; sub plot and sub-sub plot, the sub–sub plot area was 90m2 (50m × 1.8m) were separated by a distance of 2m between each sub-sub plots and by distance of 10m at the end of sub-sub plot. Amounted digger Fig. 1 was used for all the tests, the specifications of the potato crop digger was illustrated in Table 2.

Potato harvesting machine used in this research had two chain conveyors Fig.1. These types of machines are used in different areas of Sudan, especially in areas with light soils. This machine is suitable for use in above condition, but when the soil is moist and sticky, not used. The major advantage of potato harvesting machine with chain conveyor is delivering potatoes on a row in the field that will facilitate the gathering potatoes by hand, although it will not be caused a significant reduction in the number of workers needed to collect the potatoes. Compared with other types of harvesting machines, components of this type of machine have higher erosion. Dimensions properties and the specifications of machine used in this study are summarized in Table 2.

FIG. 1: Potato harvesting machine used in this research

TABLE 1

SOME OF SOIL PROPERTIES OF THE EXPERIMENTAL SITE BEFORE TEST

Depth (cm)	Bulk density (gm/cm3)	pH	Moisture content (%)	infiltration rate	Soil texture
0-25cm	1.72	7.3	7.6	6.8 cm/hr	sandy clay loam

2.3 Measurement

The following performance parameters were determined to evaluate the root drop digger

2.3.1 Crop parameters

Number of tubers per meter row length

The numbers of tubers were counted in one meter row length. The counting was done before harvesting of crop. The data was recorded at ten places selected randomly.

TABLE 2
TECHNICAL SPECIFICATIONS AND CHARACTERISTICS OF THE TRACTOR AND POTATO DIGGER

Characteristics	Description
Tractor	
Brand	Massey Ferguson
Model	480 Xtra
Engine Power	96.9 kW (130 hp)
Potato digger	
Brand	Grimme
Model	WH200
Number of rows	2
Number of conveyor	2
Working Width	1.8 m
Share shape	Trapezium
Share width	56 cm
Hitching	Three point linkage

2.3.2 Depth of crop

The data was recorded at ten random places. The depth was measured by a measuring scale after removing the soil from side of the bed.

2.3.3 Tubers lifting

The lift potato was calculated to know how much of the potato remained un-dug. It was defined as follows

$$\text{Lift potato } \% = \frac{c}{d} \times 100$$

Where,

c is the total number of digged potato.

d is the total number of potato (digged and un-dug both).

2.3.4 Cut potato

Cut potato was calculated to know the percentage of potato which was cut by the digging blade. It was defined as follows

$$\text{Cutpotato } \% = \frac{f}{d} \times 100$$

Where,

f is the total number of cut potato by the digging blade

2.3.5 Bruised and bruised index potato

Bruised potato required to know the percentage of bruised potato (skin comes cut) either by striking with soil clods or due to rubbing action while being conveyed on the oscillating conveyor. It was defined as follows

$$\text{Bruised potato}\% = \frac{e}{d} \times 100$$

Where,

e is the total number of potato which are bruised

To calculate the bruised index random samples of tubers were collected from each treatment and classified as follows:

Undamaged: tubers have no bruise and cut,

Scuffed: only skin broken, no flesh damage,

Peel damage: This can be removed by a stroke 3 mm deep of hand potato peeler.

Severe damage: This cannot remove by a 3 mm deep stroke of a hand peeler.

The total damage index (TDI) was calculated as indicated by [19].

$$\text{TDI} = \text{Scuffed x } 1 + \text{Peeler x } 3 + \text{Severe x } 7$$

2.3.6 Rear wheel slippage (%)

The tractor rear wheel slippage (S) was calculated as a percentage of loss of forward speed as in the following equation

$$S\ (\%) = \left(1 - \frac{V_a}{V_t}\right) \times 100$$

The actual travel speed (Va) for tillage was measured using stopwatch to record the time taken by the tractor to travel specific distance (100 m). Theoretical travel speed (Vt) of the tractor was measured by the same way mentioned above with the implements raised up and the tractor traveled the same distance (100 m).

2.3.7 Effective field capacity (EFC)

The actual operating time along with time lost for turning of machine were recorded in the field test area. The effective field capacity of the machine was calculated as follows

$$\text{EFC} = \frac{A}{T_p + T_1}$$

Where,

EFC = Effective field capacity, ha h-1

A = Area covered, ha

TP = Productive time, h

T1 = Non-productive time, h

(Time lost for turning, excluding refueling and machine trouble).

2.3.8 Fuel consumption

For measuring the fuel consumption of tractor, the fuel tank was filled up to neck of the fuel tank before and after the digging operation. The amount of refilling measured after the test was the fuel consumption for digging operation and it was expressed as liter per hour.

2.4 Statistical Analysis of the data

The quantitive data were quantified according to standards laid down and tabulated to draw meaningful inferences. In order to see the significance of results for un-dug, bruised, cut and digging efficiency, the data were subjected to the statistical analysis by the analysis of variance technique programme given by O.P. Sheoran (www.hauernet.in). Critical differences were also calculated at 5 per cent and 1 per cent level of significance.

III. RESULTS AND DISCUSSION

Table 3 shows the analysis of variance results related to the effects of forward speed, harvesting depth and conveyer inclination on the Tubers lifting, cut of potatoes, total damage index, wheel slippage, fuel consumption and effective field capacity of Potato Digger with Double Chain Conveyors.

3.1 Effect of operating variables of Potato Digger with Double Chain Conveyors on Tubers lifting

Table (3) indicates that, the influence of forward speed and harvesting depth on tubers lifting was highly significant at 5 percent level of confidence, where there was a significant difference when it was influenced by conveyer speed (P>0.05) (Table 3).

TABLE 3

ANOVA DESCRIPTION FOR ALL OBSERVED PARAMETERS AT DIFFERENT FORWARDS SPEED, HARVESTING DEPTH AND CONVEYER INCLINATION AND THEIR INTERACTIONS.

Observed parameters	Lifting		Damage		Scuffed		Peeler		Severe		Damage Index		Wheel slippage		EFC		Fuel consumption	
Source	P	SS	P	SS	P	SS	P	SS	P	SS	P	SS	P	SS	P	SS	P	SS
Speed	0.00	123.1	0.98	0.49	0.06	33.9	0.51	0.78	0.39	13.89	0.40	1015.5	0.47	33.81	0.00	1.89	0.00	166.01
Depth	0.00	470.3	0.00	330.1	0.00	43.8	0.12	2.21	0.00	249.9	0.00	12777.5	0.06	113.3	0.07	0.05	0.00	385.9
inclination	0.02	144.1	0.97	0.735	0.26	6.10	0.61	0.003	0.46	5.447	0.12	706.0	0.45	11.27	0.05	0.03	0.00	33.23
Speed × depth	0.00	998.9	0.71	3.93	0.01	39.7	0.92	1.21	0.42	38.47	0.60	1215.5	0.28	92.33	0.24	0.05	0.00	222.7
Speed × inclination	0.54	28.30	0.27	15.7	0.71	3.19	0.08	2.34	0.66	8.340	0.37	572.5	0.94	2.18	0.26	0.02	0.00	55.36
Depth × inclination	0.00	533.9	0.61	5.58	0.54	5.89	0.91	0.07	0.06	8.34	0.12	1293.0	0.18	72.44	0.60	0.01	0.00	39.79
Speed×Depth× inclination	0.01	409.60	0.3	28.95	0.57	13.8	0.13	3.34	0.93	7.74	0.81	420.2	0.05	225.1	0.78	0.009	0.00	67.743

EFC = Effective field capacity, P = probability SS = sum. of Square

There was a consistent decrease in the tubers lifting with increase in forward speed from Sp1 to Sp2 and Sp3. Pooled data of tubers lifting showed that forward speed Sp2 of (5.6km/hr) was having the highest tubers lifting percentage of 93% which was nearly 0.2% and 3.5% more than that at (Sp1 of 4.4km/hr) and (Sp3 of 6.7km/hr), respectively Fig. 2. Our findings with regarding to tubers lifting are in conformity with those of [20]and [21]who found that, the forward speed of digger increased resulted to the un-dug potatoes increased. The best result of lifting potatoes was found when the machine was working in Sp2.

With increase in harvesting (digging) depth, the tubers' lifting goes on increasing. Highest percentage of tubers lifting was recorded due to harvesting depth at deepest harvesting of 21cm as compared to other two depths of 18 cm and 16cm. it can be seen that as the digging depth of digger increased from 16 to 18, the lifting potatoes increased from 93.42 to 94.42%, while decreased from 94.42% to 87.72% when the digging depth decreased from 21cm to 18cm as showed in Fig. 2.

Significant and consistent increase in tubers lifting percentage was recorded due to change in conveyer inclination from inclination 1 to inclination 2 (table3). Tubers lifting percentage at inclination 2 were slightly superior to inclination by 3.49%. (Fig. 2).

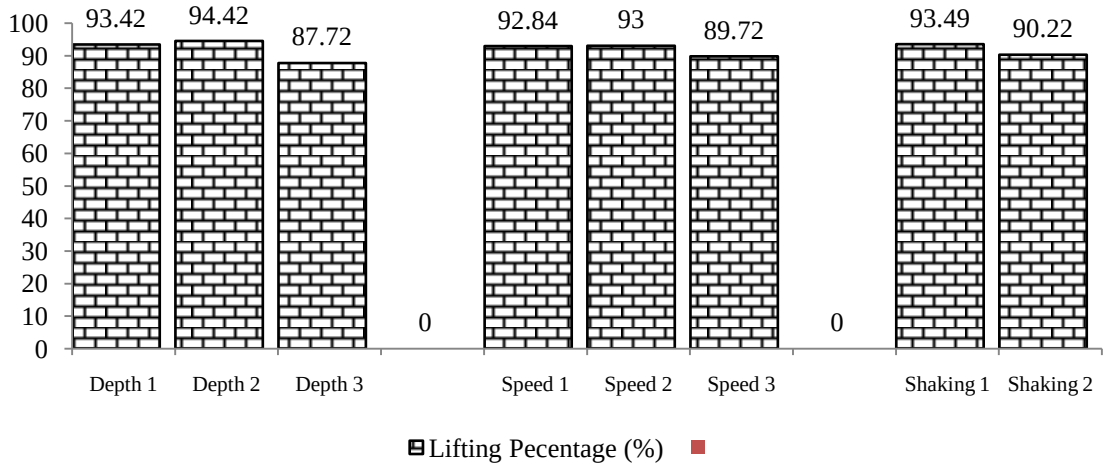

FIG. 2: Effect of operating variables on Tubers lifting percentage (%)

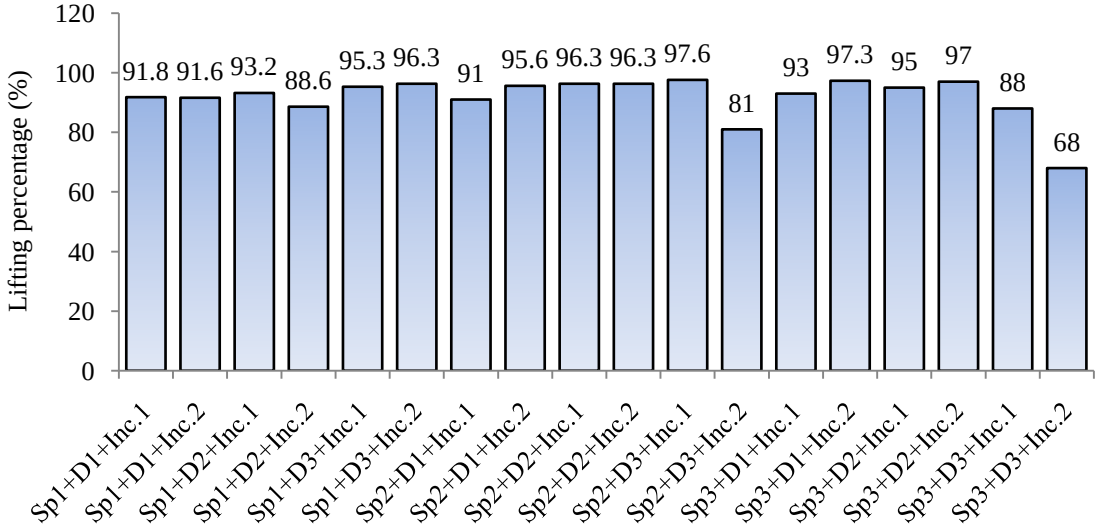

FIG. 3: Effect of interaction of operating variables on Tubers lifting percentage (%)

3.2 Effect of operating variables of Potato Digger with Double Chain Conveyors Cut potatoes

The statistical analysis of data on the influence of study variables on the cut potatoes indicated that the cut potatoes were highly influenced by forward speed at 5% level of significance and harvesting depth at 5% level of significance as indicated in Table (3), where there was no significant difference when it was influenced by conveyer inclination (P>0.05). The

interaction of forward speed and harvesting depth and the interaction of harvesting depth and inclination of conveyers were not- significant (P>0.05) as shown in Table (3).

The mean values of cut potatoes at different forward speed, harvesting depth and conveyer inclination are shown in Fig. 4, Fig. 5 and Fig. 6, respectively. From Fig. 4, Fig. 5 and Fig. 6, it can be seen that as the forward speed increased from Sp1 to Sp3 the cut potatoes increased from 2.3% to 2.5%, while it was decreased from to 5.9% to 1.2% and from 1.2% to 0.2% as the harvesting depth increased from 16cm to 18cm and from 18cm to 21cm, respectively. The increase in the percentage of the cut potatoes with increase in forward speed of the root crop digger may be attributed to the reason that as the speed increased, the fluctuation of digging blade increased and the potatoes which were at varying depth got cut by the digging blade. Similar trends of increase in cut potatoes with increase in forward speed of root crop digger have been reported by [22] and [23]. [24]reported that percentage of tuber damage decreased with the decrease in forward speed. Similarly the cut potatoes decreased from 2.6% to 2.3% as the inclination changed from inclination1 to inclination 2 (Fig. 6).

As shown in Table 3, the interaction between forward speed, harvesting depth and conveyer inclination were significant different (P>0.05).

From the obvious results which was shown in Fig.7, it may be considered that, the lowest cutting percentage of (0%) under the following treatment of Sp1 + harvesting depth3+ conveyer inclination 2, treatment of Sp2 + harvesting depth3 + conveyer inclination 1 and Sp3 + harvesting depth3+ conveyer inclination 1.

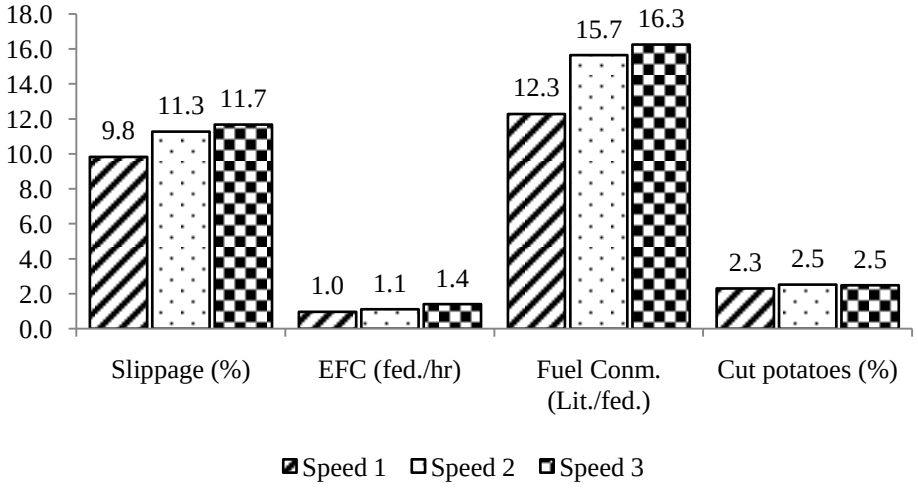

FIG. 4: Effect of different forward speed on machine performance and percentage of cut potatoes

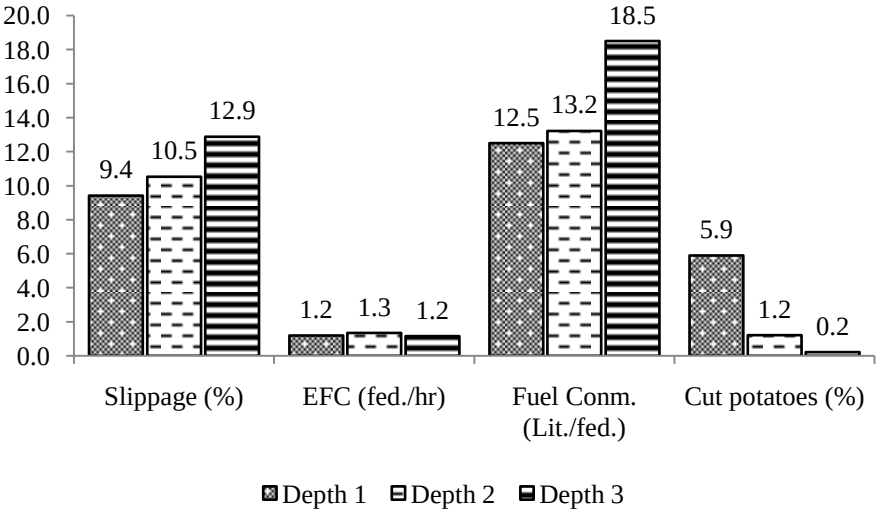

FIG. 5: Effect of different harvesting (digging) depths on machine performance and percentage of cut potatoes

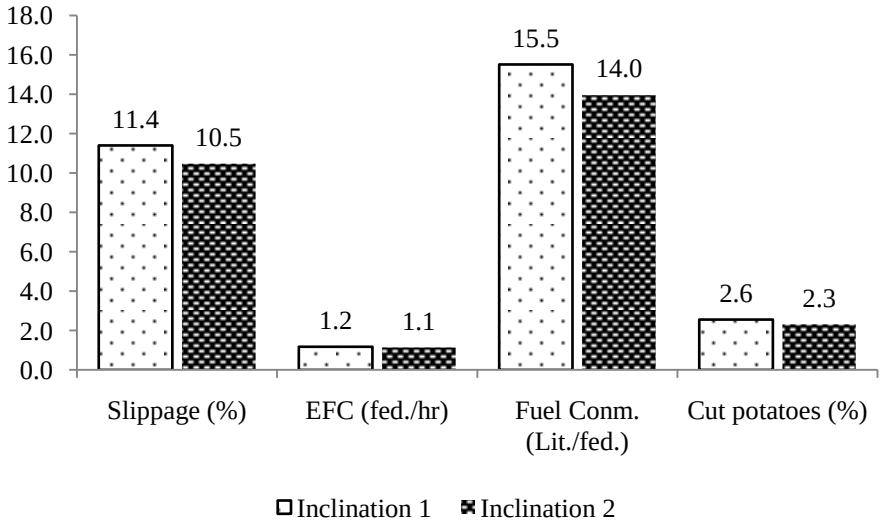

FIG. 6: Effect of different conveyer inclination on machine performance and percentage of cut potatoes

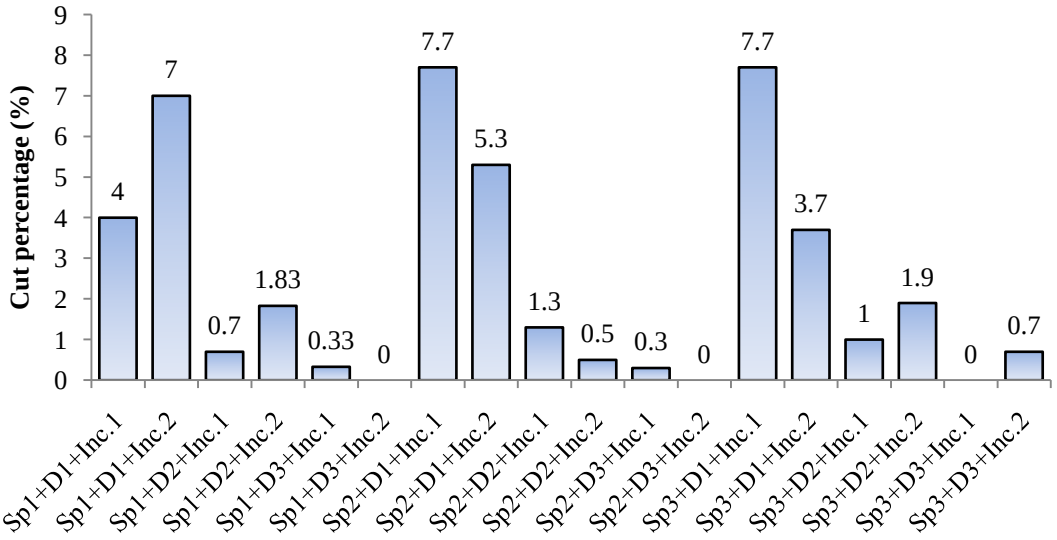

FIG. 7: Effect of interaction of operating variables on Tubers Cut percentage (%).

3.3 Effect of operating variables of Potato Digger with Double Chain Conveyors on Bruised and Total Damage (Bruised)index of potatoes tubers

The results indicated that, the increase of tractor forward speed from 4.3 to 6.7 km/h was accompanied with decreased in each of scuffed damage tubers, peeler damage tubers, severe damage tubers, total damage index tubers of potato tubers for the experimented potato digger. (Fig. 8)

There was no significant decrease in the percentage of tubers damages with increase in the forward speed from Sp1 to Sp2 and Sp3 (P>0.05) as presented in Table (3). Less percentage of scuffed, peeler, severe damage tubers and total damage index of 0.2%, 0.0%, 1.6%and 21.9 were recorded at Sp3 of 6.7km/hr, while the highest percentage of scuffed, peeler and severe damage tubers of2.1%, 0.3% and 2.7% was recorded at Sp1 of 4.3km/hr,Fig.8. This result is agrees with finding by [25], who stated that, the increase in forward speed led to decrease the bruised of the potatoes.

The digging (harvesting) depths had a highly significant effect on tubers severe and scuffed damage while showed no significant effect on peeler damage and total damage index Table (3). As shown in Fig.9 the depth of 21cm produced higher scuffed, peeler and severe damage tubers and total bruised (damage) index of 2.2%, 0.5%, 5.1% and 43.6 respectively, while the lowest scuffed, peeler and severe damage tubers and total damage index produced with the depth of 18cm. The increase

in the percentage of the potatoes total damage index with decrease in digging depth of the root crop digger may be attributed to disturbed big soil clods resulted depth increasing.

Percentage of scuffed damage tubers, peeler damage tubers, severe damage tubers, total damage index showed no significant variation due to two different conveyer inclination (inclination 1 and inclination 2), (P>0.05), Table (3). Fig. 10 showed that, the mean values of percentage of scuffed damage tubers, peeler damage tubers, severe damage tubers, total damage index at two different conveyer inclination((inclination 1 and inclination 2) which are 0.64% and 1.31%, respectively for the scuffed, 0.16 and 0.17% for peeler, 1.9 and 2.5% for severe and 14.5 and 20.1 for total damage index of different conveyer inclination respectively, this results are inline with finding by [25]who found that, the increase in chain inclination led to increase the damage of tubers.

The interaction of forward speed and harvesting depth and conveyers inclination were non- significant (P>0.05), as shown in Table (3).

Fig. 11 showed that, the best optimized values of speed-inclination combination with respect to total damage index were Sp1 + harvesting depth3 + conveyer inclination 2, Sp2 + harvesting depth3 + conveyer inclination 2 and Sp3 + harvesting depth3 + conveyer inclination 1.

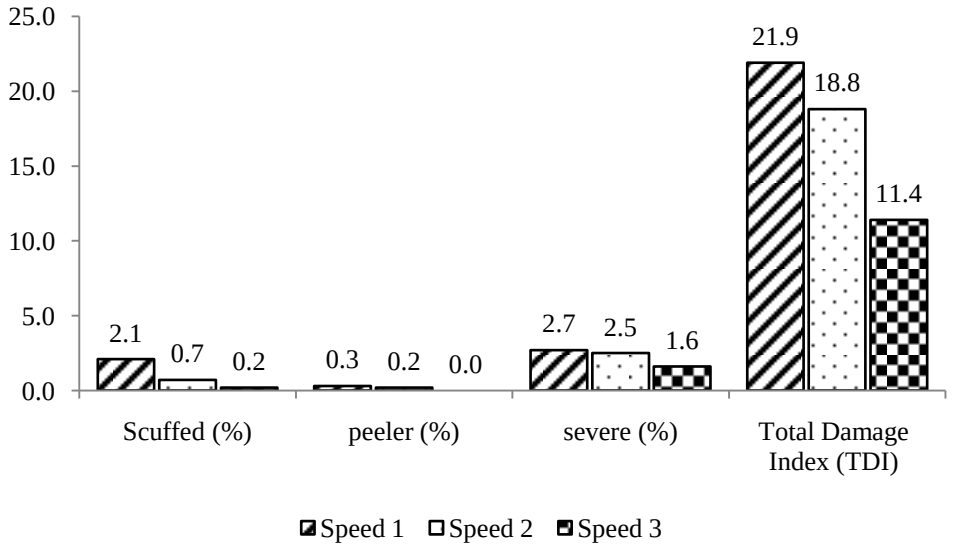

FIG. 8: Effect of different forward speed on bruised potatoes parameters and potato total damage index

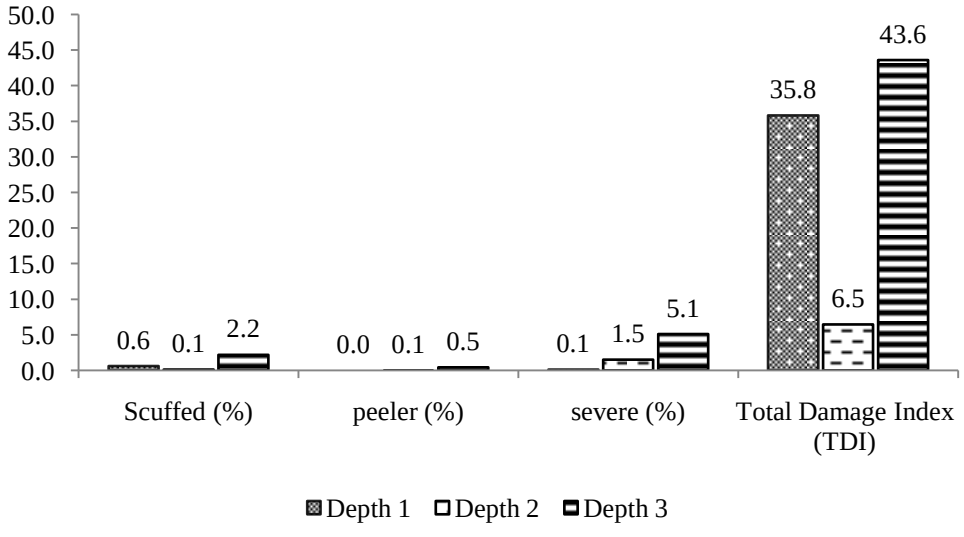

FIG. 9: Effect of different harvesting (digging) depths on bruised potatoes parameters and potato total damage index

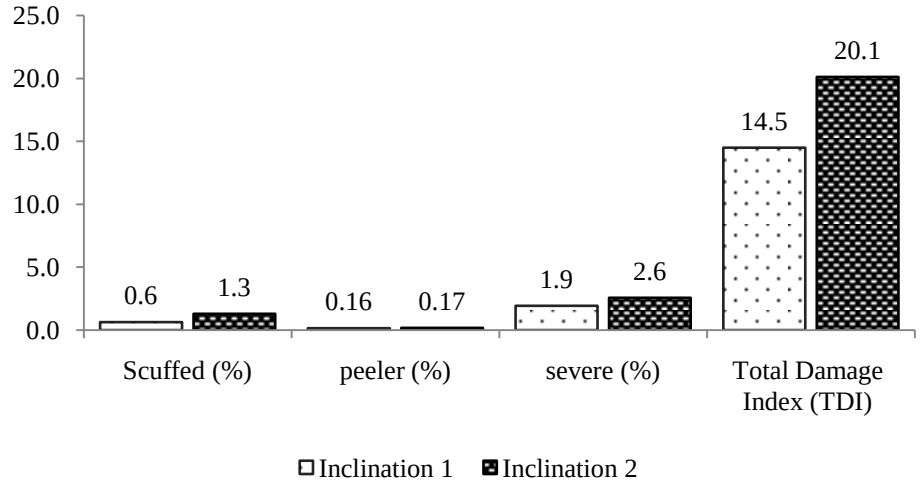

FIG. 10: Effect of different conveyer inclination on bruised potatoes parameters and potato total damage index

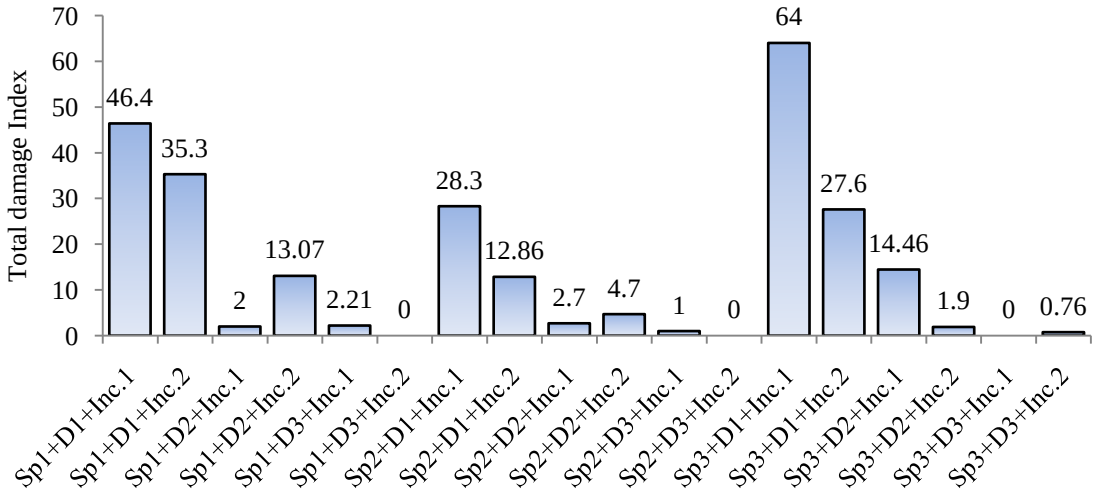

FIG. 11: Effect of interaction of operating variables on Total Damage Index (%)

3.4 Effect of operating variables of Potato Digger with Double Chain Conveyors on wheel slippage

Mean comparison between the averages of Travel reduction or wheel slippage in different forward speed by statistical analysis showed that increasing the forward speed, increased wheel slippage not significantly (Table 3). These results are in agreement with the findings of other researchers[26],[27]and [28]. The interaction effect of forward speed and digging depth was not- significant as indicated in Table (3).

Travel reduction or wheel slip is one of the major parameters affecting the tractive efficiency of a pulling machine. Wheel slippage at different levels of speed designated as Sp1, Sp2 and Sp3 for 4.4, 5.6 and 6.7 km/hr, respectively are shown in Fig. 4which are 9.8%, 11.3% and 11.7%. There was positive linear correlation between speed and travel reduction. Travel reduction was high at high speeds and decreased with decrease in speed.

The statistical analysis performed on travel reduction as affected by digging depth showed there is no significant difference ($P<0.05$). The interaction effect of digging depth and conveyer shaking showed also no- significance different which was presented in ($P<0.05$) Table (3).Fig. 5 shows the mean comparison between travel reductions (wheel slippage) in different digging depth. It is clear that by increasing digging depth the travel reduction of potatoes digger increases. The travel reduction of potatoes crop digger as shown in Fig 5 were 9.4, 10.5 and 12.9% were obtained at depth 1, depth2 and depth3, respectively. It may be due to this reason that increasing the digging depth resulted in an increase in dimension and soil tear.

The percentage increases in travel reduction with changing in inclination 1 to inclination 2 were 11.4 and 10.5%, respectively Fig 6. The values of travel reduction were non-significant at two different of conveyer inclination (P<0.05) as indicated in Table 3.

The interaction effect of forward speed, digging depth and conveyer inclination were also show not-significant as indicated (P>0.05) in Table (3).

Fig. 12 showed that, the treatment of Sp2 + harvesting depth2 + conveyer inclination 1, may be considered as best optimized value for wheel slippage percentage (5.9%) of the potato crop digger.

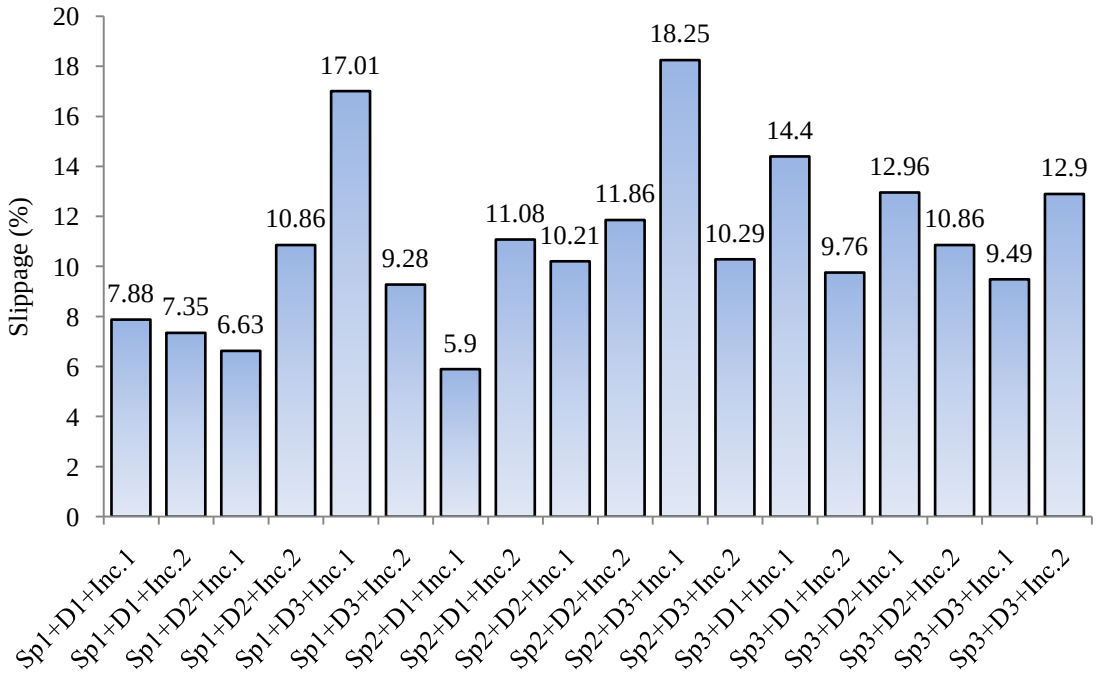

FIG. 12: Effect of interaction of operating variables on wheel slippage (%).

3.5 Effect of operating variables of Double Chain Conveyors Potato Digger on effective field capacity

Effective field capacity (EFC) showed highly significant different due to forward speed Table (3).. There was an increasing in the effective field capacity with increase in forward speed from Sp1 to Sp2 and Sp3. Collected data of EFC indicated that the highest EFC of 1.4 ha/hr was recorded by Sp3 of 6.7km/hr which was 21.4% and 35.7% greater than that at Sp2 5.6km/hr and Sp1 4.4km/hr, respectively, as shown in Fig.4. This increase in the EFC with increase in the forward speed might be due to that fact, field capacity is mainly affected by speed travels in the field, time losses and width of machine and this agrees with [29]and [26].

Over the course of the study, different digging depths of the potatoes digger significantly different (P<0.05) affected EFC (Table 3) and Fig. 5. The EFC as affected by different digging depths (depth 1, depth2 and depth 3 are displayed in Fig. 5. There was a trend for EFC to decrease with increasing digging depth. From Fig. 4 it can be seen that as the digging depth of digger increased from 16cm to 21cm, the EFC decreased from 1.3ha/hr to 1.2ha/hr, respectively. This decrease in the EFC with increase in the digging depths might be due to; by increasing the depth, soil texture becomes more coherent. Also, traction force is related to the friction between blades and soil, so that by increasing the plowing depth, the force of soil weight on blades increases and it resulted to increase in friction.

In order to determine the effect of conveyer inclination on effective field capacity the variance analysis was presented in Table (3). The analysis showed that the conveyer inclination has no significant on effective field capacity. The maximum EFC of 1.2ha/hr was obtained by inclination 1 while inclination 2 recorded lowest EFC (1.1ha/hr) as shown in Fig. 6, It's clear that the average EFC of inclination 1 was found slightly superior than that of inclination 2 by8.3%.

The interaction effect of forward speed and digging depth also the interaction effect of digging depth and conveyer inclination were also non-significant as indicated in Table (3).

As shown in Table 3, the interaction between forward speed, harvesting depth and conveyer inclination were not significant different (P>0.05).

From the obvious results shown in Fig.13, it may be considered that, the better EFC value of (1.56fed/hr) could be obtained under the following treatments of Sp1 + harvesting depth3+ conveyer inclination 1.

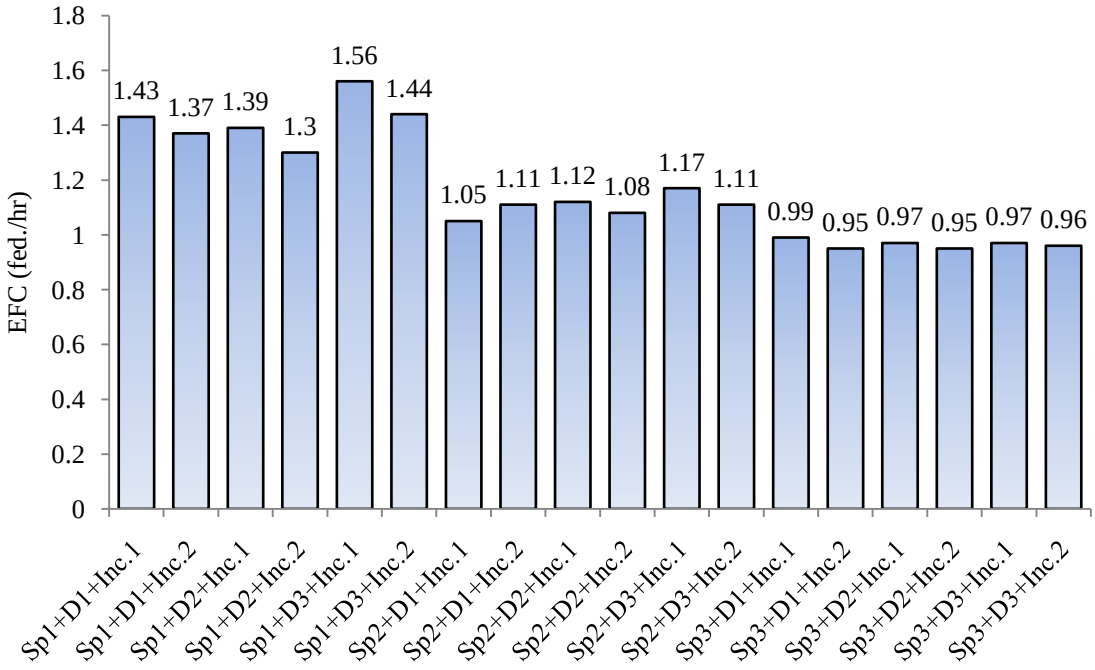

FIG. 13: Effect of interaction of operating variables on EFC (fed.hr)

3.6 Effect of operating variables of Potato Digger with Double Chain Conveyors on Fuel consumption

The values of fuel consumption were highly significant for different forward speed as indicated in Table (3). The interaction effect of forward speed and Harvesting depth and interaction of forward speed and conveyer inclinations and other interactions were also highly significant as indicated in Table (3). The details of the values of fuel consumption affecting by forward speed are given in Fig. 4. From Fig. 4 it can be seen that as the forward speed increased from Sp1 to Sp2, and from Sp2 to Sp3 the fuel consumption increased from 12.3 to 15.7 lit/ha and from 15.7 to 16.3 lit/ha, respectively. This result is agrees with[27];[26] who found that, there were a positive relation between forward speed and fuel consumption.

The effect of harvesting depth was also highly significant for different depth affecting the fuel consumption as indicated in Table (3). The interaction effect of harvesting depth and conveyer inclination was also showed non- significant different as indicated in Table (3).

The result showed that the average fuel consumption in the deepest depth was generally higher compared to lower depths. The average fuel consumption of 18.5 Lit/ha which recorded for the depth3 was observed to be higher than (Depth 2) and (Depth 1) by 28.6% and 32.4%, respectively, (Fig. 5). This result may be due to, By increasing the harvesting depth, more power is need to cut and transfer soil, so that lead to increase the fuel consumption and wheel slippage [30]. Similar results were found by [31]. Another reason for increasing the fuel consumption which is the tractor draught would be this fact that increasing digging depth will cause increasing the soil tear, bulk and mass, so that more power is need to cut the soil

Similarly a decreasing trend was observed for the fuel consumptions from 15.5 Lit/ha to 14 Lit/ha as the conveyer inclination changing from inclination 1 to inclination 2, Fig.6. Table (3) indicates that the influence of conveyer inclination on fuel consumptions is significant at 5 percent level of confidence.

The interaction effect of forward speed, digging depth and conveyer inclination was also significant as indicated in Table (3). The best optimized values of fuel consumption of (7.95lit/ha) may obtained from the combination of the following treatments Sp1, Depth 2and Inclination2 (Fig.14).

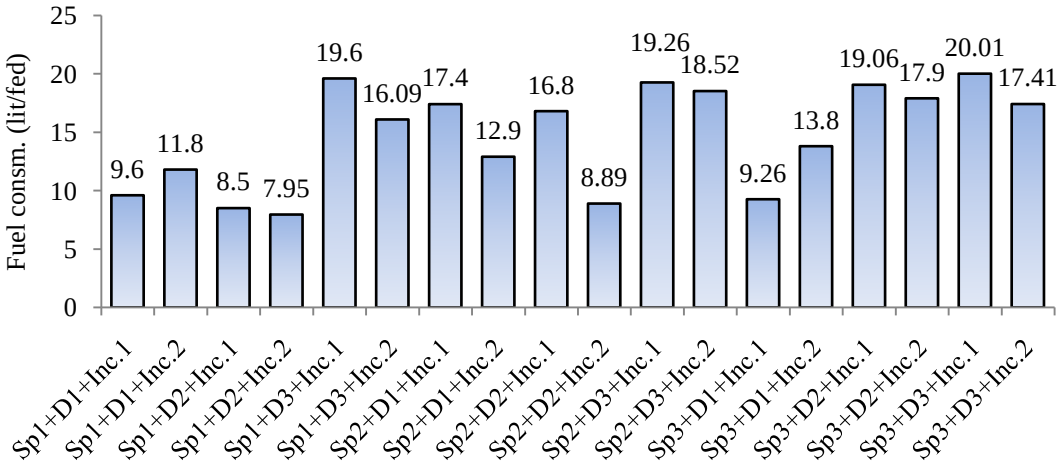

FIG. 14: Effect of interaction of operating variables on Fuel consumption (lit./ha)

IV. CONCLUSION

1) The percentage of lifting potatoes, cut of potatoes, Bruised and Total Damage index potato and some of machine performance such as travel reduction (wheel slippage), effective field capacity and fuel consumption as affecting by different forward speed, harvesting (digging) depth and conveyer inclination were measured and evaluated.
2) Forward speed Sp2 of (5.6km/hr) was having the highest tubers lifting percentage of 93% which was nearly 0.2% and 3.5% more than that at (Sp1 of 4.4km/hr) and (Sp3 of 6.7km/hr). furthermore, as the forward speed increased from Sp1 to Sp3 the cut potatoes increased from 2.3% to 2.5%, on the other hand, less percentage of scuffed, peeler, severe damage tubers and total damage index of 0.2%, 0.0%, 1.6% and 21.9 were recorded at high speed of 6.7km/hr, while the highest percentage of scuffed, peeler and severe damage tubers of 2.1%, 0.3% and 2.7% was recorded at lower of 4.3km/hr.
3) the treatment of Sp2 + harvesting depth2 + conveyer inclination 1, may be considered as best optimized value for potato lifting percentage (97.6%) of the potato crop.
4) The best optimized values of speed-inclination combination with respect to total damage index were Sp1 + harvesting depth3 + conveyer inclination 2, Sp2 + harvesting depth3 + conveyer inclination 2 and Sp3 + harvesting depth3 + conveyer inclination 1.
5) The best optimized values of fuel consumption of (7.95lit/ha) may obtained from the combination of the following treatments Sp1, Depth 2and Inclination2 and the better EFC value of (1.56fed/hr) could be obtained under the following treatments of Sp1 + harvesting depth3+ conveyer inclination 1.
6) With increase in harvesting (digging) depth, the tubers' lifting goes on increasing, while the cut of potatoes was decreased from to 5.9% to 1.2% and from 1.2% to 0.2% as the harvesting depth increased from 16cm to 18cm and from 18cm to 21cm, respectively. The depth of 21cm produced higher scuffed, peeler and severe damage tubers and total bruised (damage) index of 2.2%, 0.5%, 5.1% and 43.6 respectively.
7) Consistent increase in tubers lifting percentage, the mean values of percentage of scuffed damage tubers, peeler damage tubers, severe damage tubers, total damage index were recorded due to change in conveyer inclination from inclination 1 to inclination 2, while decreased from 2.6% to 2.3% as the inclination changed from inclination1 to inclination 2.

ACKNOWLEDGEMENTS

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Predicting of Field Working Days of Planting and Harvesting Operations for Sorghum Crops Damazeen Area (Sudan)

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Abstract— *Prediction model was developed to predict suitable field workdays for planting and harvesting operations in South Central Sudan (Damazeen). Predictions were made from a computer model which simulates daily soil moisture in the top 30 cm of soil depth using 11 years of daily meteorological records. The model was tested and validated by comparing its output with the observed workdays during the 2004 farming season on Clay soil types. Results show that there was good agreement between the observed and predicted values using established tractability criteria. A study was conducted to determine the appropriate number of working days in mechanized planting and semi-mechanized harvesting of Sorghum in Damazeen, Sudan in 2010. The number of working days for mechanized planting was estimated about 20 days, and for harvesting was about 23 days with 99% confidence. The allowed limit of soil moisture in clay-loam texture, for having the capability of running field operations was determined to be 14.5% of the weight. In this limit, soil has acceptability of 6.34 mm of water (rainfall) for sowing and 10.62 mm for harvesting at the depth of operation in each turn of rainfall or irrigation. At sowing and harvesting times, 19.3% and 7.5% of the rainfall is converted to runoff. Therefore, the maximum allowable rainfall in a situation that doesn't change the soil condition from the proper situation for mechanized sowing and harvesting operation is 7.6 and 11.41 mm, respectively, in each rainfall turn. For the drainage of excess moisture after rainfall, in sowing and harvesting operations, five and seven days are required, respectively.*

Keywords— simulation model, drainage, proper working days, runoff, soil profile tractability.

I. INTRODUCTION

The most uncontrollable variable in agricultural operations is the number of proper working days in a cropping year. A method for determining the appropriate working days is to obtain a reasonable relationship based on the previous year's temperature and rainfall. This method of probability distribution clarifies the appropriate dates for each key activity throughout a year. Field capacity and climate conditions are the main factors for determining the appropriate time for agricultural operations during the year. The required time for working with field machinery depends on the machine capacity and the number of appropriate working days. Each region of the country has its own climate pattern. Working days of the field is determined by two factors. First, the soil moisture content should not exceed the plasticity limit; second, the rainfall on that day should not be greater than 10 mm. The effect of other climate conditions such as freezing occurrence probability or snowing are not included in the analysis of soil working days (Witney 1988).

Adverse soil condition makes it difficult or impossible to perform some field operations. Suitable days, being related to random weather related events, are thus also random in nature. Information about the probability distribution of suitable days during critical production periods would help farmers determine their optimal machinery complement and crop mix. Probability of a working day (PWD) is the fraction of workable days to all days in a work season, which often is used in management of agricultural mechanization. For example it is used to determine timeliness cost, optimum capacity of a machine and the required machine capacity (Saglam and Ibrahim, 2011). Accurate information on the number of suitable days for field operations is important in design, development, and selection of efficient machinery systems for crop production (Khan et al., 2011). In order to predict the amount of work that can be accomplished, the time available within the optimal period for the required operation must be known. The time available varies considerably from year to year as weather conditions vary. Selection of the optimal machinery set for long-term production on the farm depends upon accurate assessment of the days available for performing each field operation (Rotz and Harrigan, 2005). The most restrictive factor

for harvesting operation is the soil moisture. Soil moisture content and the vagaries of weather are the two major factors which determine the amount of time available throughout the year for field operations (Witney, 1988).

In a poor season, little time may be available for performing one or several field operations under acceptable conditions. A favorable weather pattern and a friable soil, provide available or possible time within which the field work can be completed without working excessively long hours, or working in unsatisfactory conditions he weather interacts both with the soil to vary soil workability for tillage operations and with the crop to vary yield and moisture content at maturity for harvesting operations, whilst the influence of the weather on soil tractability affects all operations to a greater or lesser extent. The workability / trafficability of the soil is dependent on the soil moisture content which can be evaluated from soil and weather variables (Witney, 1988).Provided that all the relevant operating conditions can be specified for the soil and the crop, suitable workdays can be identified. As a preliminary stage, commonly accepted operational times are used to provide workday data for strategic planning purposes. It is common practice with respect to farm operations within the savannah agro-ecological zone of Nigeria to find farmers using their intuition and traditional knowledge acquired from their mentors, using unconventional methods in estimating suitable field workdays rather than the scientific methods which are more reliable and dependable. The scientific methods are more useful in estimating suitable field workdays for better farm yield or benefits. Thus, it is the aim of this paper to collated useful weather, soil moisture and soil conditions (soil liquid and plastic limits) parameters using soil moisture budgets empirical methods which was then programmed using Virtual Basic 2008 to segregate the suitable and non-suitable workdays for planting and harvesting operations on a mechanized maize farm. Available time for any field operation is a function of a suitable workday. Cooper et al., (1997) stated that the time available for completion of field work depends on such factors as weather, soil characteristics, hours worked per day, number of days allowed for completion of field operations, scheduling efficiency, machine reliability and field efficiency. Principally, soil moisture budget.

A significant part of the annual rainfall occurs in summer during sorghum sowing and the sowing date has a significant influence on final yield and in case of delay in operation, the farmers face the extra costs as a result of not performing operations in a timely manner. Dura is a staple food crop, highly delicious and balanced nutritiously. It is a good source of carbohydrates, Vitamins and Irion etc. According to Dura Swing and harvesting operations, there is an optimum time. Period for swing and harvesting to ensure maximum crop yields. If the crop is planted at a time other than within the determined periods this will lead to reduction in yield. When the crop matures, and is not harvested within the optimum time, this will lead to field losses that may increased by unfavorable weather conditions. Therefore, it is very important for farmers to be aware of the number of the days in which mechanized sowing and harvesting can be planned. The most important factor which limits the time of sorghum sowing and harvesting, in farming calendar, is the soil moisture (Bazyar2004).

The general objective of this study was

To determine the number of appropriate working days for sorghum sowing and harvesting in Damazeen area.

The specific objectives are:

1- To determination of the threshold for allowable limiting factor (soil moisture) in sorghum sowing and harvesting

2- Determination of the effective parameters which may change the limiting factor.

3- Determination of the appropriate number of working days for sorghum sowing and harvesting according to limiting factor.

II. METHODOLOGY

The approach used in this study was to study agro-meteorological data obtained from Damazeen Meteorological Station and discuss the usefulness of these in agricultural watershed management. In particular, the problem of predicting suitable field workdays (SFW) was addressed. A model was developed for this purpose based on soil moisture budgeting and established tractability criteria. The model was applied to the watershed under study using agro-meteorological and other data for a period of time. The predicted results were compared with actual observed data on SFW. Details of this procedure are presented subsequently.

2.1 Agro-meteorological and Other Observations

The determination of SFW requires agrometeorological and hydrological data which must be obtained on a daily basis over a period of time. Some data were obtained from the meteorological station while others were obtained by direct measurements.

Since the meteorological station at Damazeen agrometeorological data have been recorded on a continuous basis. These include time, amount and duration of rainfall, wind speed and direction, sunshine hours, open pan evaporation, air temperature and soil temperature. Other measurements include runoff, soil moisture, field capacity, permanent wilting point and actual available field workdays. Runoff at various seasons was obtained from standard runoff plots under conventional tillage practice for the area. Daily soil moisture was obtained by sampling from Damazeen experimental farm. The moisture content was determined by the gravimetric method. Actual observed SFW were obtained by following the activities of the Farm Management Unit of area of the study. Days in which field work could not be done due to rain, too high moisture or too low moisture were recorded. These observations started in August 2004 and are on a continuous basis in order to generate a long term data.

2.2 The Water Balance Model

A model was developed based on the concept that the available soil moisture is a function of previous precipitation, irrigation, drainage, evapotranspiration and surface runoff. The soil moisture content on

any particular day is the difference between what it was the previous day plus any addition through precipitation or irrigation and the losses through runoff, drainage, and evapotranspiration. Thus, daily soil moisture was estimated.

2.3 Soil Tractability Criteria

Soil tractability is the ability of a farm land to permit a machine to operate and perform its function efficiently without damaging the soil. For operations that involve soil engaging, such as planting and harvesting , the soil is tractable if it has sufficient bearing strength to support the weight of the machine, can develop adequate shear resistance to avoid slip and soil damage and can produce a good soil tilth without the formation of large clods. This soil behavior varies with soil types and the operation being carried out. It is also dependent on the soil moisture status. Based on literature and actual field observation of machinery operations at DAMAZEEN, the following criteria were used for deciding when soil is tractable:

a) Moisture content in the top 30 cm of soil depth not more than 80% of field capacity

b) Moisture content in the top 30 cm of soil depth not less than permanent wilting point.

C) If the previous day was a workday and today's precipitation was no more than 10mm.

Any day in which the soil is tractable using the above criteria is regarded as a suitable or available workday.

TABLE 1
RESULTS OF ANALYSIS ON SOME PHYSICOCHEMICAL PROPERTIES OF THE SOIL IN THE STUDIED AREA.

OC%	P ppm	EX.Ch.Cations Meq/100g			CEC Meq/100g	ESP	$Caco_3$	Texture (%)		
		Na	K	Ca+Mg				Clay	Silt	Sand
0.3	6	4	0.8	38	43	6	4	72	18	10

The following equation calculates the maximum soil moisture capacity

Step one:-

Actual Evapotranspiration (AET) according to (equation no 1):-

$$AET = ETP \times KD \times KR \times KS \quad (1)$$

By this equation we can determine the Evapotranspiration (for type of soil clay – loamy) at rainfall area where:

ATE = actual evapotranspiration (mm/day).

Kd = 0.55 (soil dryness factor) according to Adam and far brother (1977).

Kr = 0.55 (rain fall correction factor) according to schwabe (1966).

Ks = 0.4, 0.5, 0.8 in June, July, August) respectively (Soil Cover factor) assumed.

Step two:-

Determine runoff (Q):-

If the amount of rain fall (Ra) is enough to cause runoff then calculate runoff by equation no (2) with excel.

$$Q = (Ra - 0.2S)^2 / (Ra + (0.8S) \quad (2)$$

where:

Q = Runoff (mm / day) depth.

Ra = annual of rainfall (mm/day).

S = soil storage parameter was determined according to

$$S = (25400/RCN) - 254 (3)$$

Where:

RCN = runoff curve number was 89 as per schwabe (1966).

S = (25400/89) - 254 = 31. 39

Step three:-

Calculate drainage:-

Determine maximum Soil capacity (W or FC):-

The soil capacity to accept moisture up to field capacity (fc) / mm.

$$w = (c - pwp) \times z \times d)/100 \quad (4)$$

Where:

W =height of water (cm) until Z cm of the soil depth. i.e. the soil capacity to accept moisture in the appropriate mode of operation. = the weight of the soil moisture storage capacity (field capacity).

C=soil moisture in appropriate mode for machine operation which was estimated between 14 to 16% for heavy textured soil (Bakhtiari 1997).

Pwp=weight of soil moisture at permanent wilting point which was considered 10.2% in study (ZarinKafsh 1998).Z = soil root zone depth (cm).D = soil depth (cm), Drainage is calculated using the equation No (5).

$$D = (smp + Ra + Fc)/(2 \times pwp) \quad (5)$$

Where:

D = drainage (mm/day).

Smp = soil moisture potential (percentage) 80%.

Pwp = permanent wilting point.

Step four:-

From Smp, Ra, AET, D and Runoff the program will calculate the soil moisture content (Sm) of a specified day according to equation no (4)

Calculate soil moisture content (Sm) (mm/day).

$$Sm = Smp + Ra - Ru - D - AET (6)$$

(All parameters define above).

Equation no (4) which has been developed from the equation

Ma = Mp + Qp + Qr + Qd + Qe as given by witney, B.(1988) where

Ma = soil moisture of a specified day.

Np = soil moisture in the previous day

Qp = daily rainfall

Qr = Runoff

Qd = drainage

Qe = actual evapotranspiration

Step five:-

To determine the soil work ability for planting and harvesting operation in particular day, the following criterion was adopted:-

If the soil moisture content (Sm) of that day is > 80% of the soil capacity (Fc) the program will write (No) (no working day) and if it is <=80% of the soil field capacity it will write (Yes) (working day).

Step six:-

The output data include all the input data as well as estimated soil moisture, an indication of whether the day is a good or bad workday (1 or 0), and the total SFW for the time period studied. The programme was designed to be interactive and allows the user easy access to the input data file so that records can easily be updated or changed.

2.4 Computer Implementation

A computer program was written in Visual Basic 2008 language designed to compute daily soil moisture content for the period beginning May and to ending October for each year of the ten years of the study period and to further apply tractability conditions to the soil moisture balance to estimate good machinery field work days and days best suited for planting and harvesting at damazeen farms. The computer program used climate and soil information for the area to estimate suitable workdays for agricultural machinery. The flow chart for the programme is shown in Fig. 1. It starts by initializing control parameters namely the starting date for the simulation, moisture content on the starting date, and time frame for the simulation. The meteorological data of interest are then read from a data file. These include rainfall, pan evaporation, relative humidity, maximum and minimum temperature, and soil temperature. The ractability conditions are set as described earlier. The next stage in the programme is to estimate daily soil moisture. First, the moisture content of the soil on the previous day is established. This is followed by establishing the precipitation for the present day from the values already read. Runoff is next determined followed by drainage (equation 3).

2.5 Model Validation and Application

Daily meteorological data for the period April through October, 2004 were used to validate the model. These were the months for which there was available data, especially soil moisture and actual observations of suitable field workdays. It was very important to test the predictive ability of the model before it could be adopted in any further study. Once an acceptable prediction is obtained on available data, projections can be made into the future by incorporating probability principles in predicting the relevant model parameters. Thus, the model was tested by comparing its predicted with observed suitable field workdays for heavy clay soils of south Central Sudan. For statistical confidence, the predicted and observed SFW were subjected to regression and correlation analyses.

III. RESULTS AND DISCUSSIONS

3.1 Number of appropriate working days for planting machine

According to Table 4, sowing calendar of Sorghum (April) was divided into 5 days groups, and in each group, number of the days in which rainfall was more than 7.6 mm (allowable rainfall) in addition to 5 days needed for field capacity differed in the number of the days in that group. The remained days were working days and in the same way, working days were

calculated for different years. Then, the statistical parameters were estimated for each group. Since the t value for confidence level of 1% and degree of freedom of 10 (number of years minus one) were obtained from Table t, appropriate working days for each group were placed between the high and low levels ($p<0.01$). Therefore, average sum of the two categories thresholds was determined in calendar ($p<0.01$). In this study, estimated number of these days was 19.69 days (Table 2).

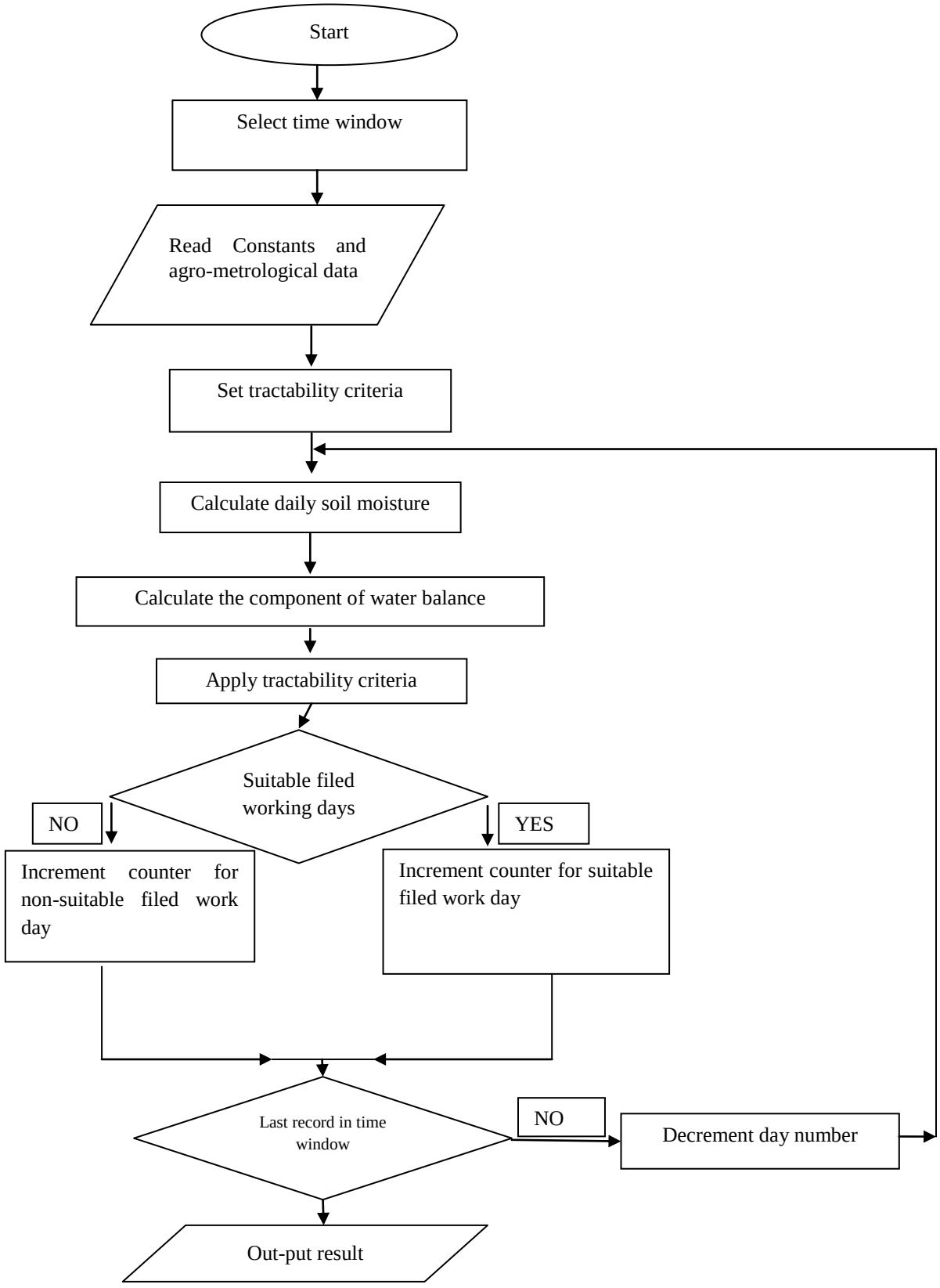

FIG. 1: Flow Chart of Suitable Field Workday Programme

3.2 Proper working days for harvesting machine

According to Table 3, number of the days in which rainfall was higher than 11.41 mm (allowable rainfall) at harvest (November) plus seven days for soil moisture to reach the appropriate mode of operation differed from the number of days in each group and remained days were considered as working days for that group. Number of working days for each year took the same way. Then, mean and standard deviation for appropriate working days in each category were obtained and t value with 1% probability and 18 degrees of freedom were obtained from Table t and upper and lower limits of each category were deter-mined. Appropriate working days are between these two limits ($p<0.01$). Therefore, considering the grand mean of the two categories thresholds, with 99% probability, proper working days for machine will be determined in farming calendar. Based on Table 3, number of these days was 23.22. Estimated t value at 1% probability and 11 degrees of freedom was equal to 1.33. Number of working days for mechanized planting and semi-mechanized harvesting operations in Damazeen province were 19.69 and 23.22, respectively, with 85% probability in clay-loam soil. To predict the number of machines in order to timely complete the operation and prevent the costs due to failure in timely operation, it is essential to be aware of the planting acreage and the machine working capacity as well as the number of proper working days.

TABLE 2
NUMBER OF APPROPRIATE WORKING DAYS IN A CALENDAR FOR MECHANIZED SORGHUM SOWING IN DAMAZEEN AREA

Source		Number of working days in mid-April in 5-day groups			Number of working days in second late-April in 5-day groups		
	Symbol	16-20	21-25	26-31	1-5	6-10	11-15
Average	X	4.11	3.27	3.16	2.77	2.83	3.55
Correction factor	Cf	304.22	193.38	180.5	138.88	144.5	277.55
Sum of squares	SS	45.78	77.62	98.5	67.12	74.5	62.45
Degree of freedom	DF	10	10	10	10	10	10
Variance	S^2	2.69	4.56	5.79	3.94	4.38	3.67
Standard deviation	S	1.64	2.13	2.4	1.98	2.09	1.91
Higher threshold	L	8.86	9.44	10.11	8.5	8.88	9.08
Lower threshold	L^-	-0.64	-2.9	-3.79	-2.96	-3.22	-1.98
Number of working days for each group	Medium	4.11	3.27	3.16	2.77	2.83	3.55

TABLE 3
NUMBER OF PROPER WORKING DAYS IN AGRONOMICAL CALENDAR FOR SEMI-MECHANIZED SORGHUM HARVESTING IN DAMAZEEN AREA.

Source		Number of working days in mid-April in 5-day groups			Number of working days in second late-April in 5-day groups		
	Symbol	16-20	21-25	26-31	1-5	6-10	11-15
Average	X	5	3.69	3.69	3.23	3.15	3.46
Correction factor	Cf	407.57	320.2	222.36	183.21	236.26	195.84
Sum of squares	SS	26.43	51.79	88.64	89.79	72.74	73.16
Degree of freedom	DF	10	10	10	10	10	10
Variance	S^2	1.46	2.87	4.92	4.98	4.04	4.06
Standard deviation	S	1.19	1.69	2.21	2.23	2	2.01
Higher threshold	L	8.42	9.55	10.05	9.64	8.9	9.24
Lower threshold	L^-	1.57	-0.17	-2.67	-3.18	-2.6	-2.32
Number of working days for each group	Medium	5	4.69	3.69	3.23	3.15	3.21

IV. SUMMARIES AND CONCLUSION

A simulation model was developed to predict suitable field workdays for soil tillage operations in Ilorin, south Central Sudan using established tractability criteria. The model was validated by comparing its predictions with observed suitable field workdays data for Ilorin on two soil types, namely sandy loam and clay. There was good agreement between the predicted and observed field workdays data. Despite the minor deviations of the predictions from the observed data, it can be inferred that the model is a veritable tool for predicting suitable field workdays for tillage operations. Because information on suitable field workdays may be crucial to farm managers during those periods of the farming season when weather and soil conditions might cause delay in farm operations, the need for this information becomes imperative for planning purposes. Equipped with this information, the farm manager could make better decisions with respect to machinery/equipment selection and scheduling of field operations in order to optimally utilize available time. A major strength of this prediction model is that virtually all the input parameters were either measured or determined at the experimental site.

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Environmental study of the role of anthropogenic factors on the possible pollution of coastal marine waters in Dakhla Bay – Morocco

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Abstract— *The sites used for breeding and the beaches are ranked in descending order of health in 4 categories A, B, C and D according to the estimate of the microbiological quality and evaluation of the chemical contamination (circular 15.08.12 d 'August 2012). After classification, the target areas are subject to regular health surveillance, intended to verify the durability of the characteristics that have based their classification and to detect possible episodes of contamination. This monitoring covers the measurement of microbiological, chemical (heavy metal) and marine biotoxin parameters in bivalve molluscs, as well as phytoplankton pests in seawater.*

The Main objective of the present survey is to make a diagnosis of the state of health of the principal beaches of the region of Dakhla Oued Eddahaba bay in years 2015, 2016 and 2017. Our sampling focused on 4 beaches: Foum Lbouir, El Moussafir, Lakeira, and Tourist Area. Bacteriological analyzes were conducted to identify the microorganisms that are indicative of faecal pollution including faecal coliforms, faecal streptococci and Escherichia coli and their enumeration by the filter membrane method on nutrient media Tergitol7 Agar, Litsky, Slanetz & Bartley.

In addition to microbiological monitoring of seawaters, the air temperature was measured "in situ" using a mercury thermometer, the temperature of the water using a pH meter, the tide (high or low) and finally the estimate of the number of bathers.

*The Main results obtained made it possible to classify the four beaches in 3 categories according to the Moroccan standard for monitoring bathing water quality NM 03.7.200. The beaches of the Al Moussafir and Tourist PK25 are classified **A**. The beaches of Foum Lebouir with medium quality waters is classified **A** or **B**. Only the beach of Lakheira is very polluted and classified in category **C**.*

Keywords— Coast, Beaches, Swimming, Pollution, Microbiology, Coliforms, Streptococci, Dakhla, Morocco.

I. INTRODUCTION

The Moroccan coastline is a diverse, fragile area and today is very much threatened by profound urban and tourist pollution. With a coastline of approximately 3500 km, developing on two Atlantic and Mediterranean maritime facades, the Moroccan coastline occupies a privileged place at the level of the entire coastline of the African continent. The wealth, associated with the strategic space that represents the littoral, made of this last one a major space of development of the country in terms of urbanization, industrial zones and tourist equipments.

The Moroccan coastline is obviously a heritage of great importance for the country. It represents a Mediterranean facade stretching about 460 km from Tangier to Saidia and an Atlantic facade of 2500 km from Tangier to Lagouira.

It is a strategic area with a wide variety of natural and biological resources, including beaches, dunes, lagoons and wetlands. It is under increasing demographic pressure from urban agglomerations and the influence of various industrial, port and tourist activities.

Morocco has a strong tendency to urbanization estimated at 4.4% per year, which is accompanied by a phenomenon of coastalisation of the population. The expanding coastal agglomerations provide the bulk of urban growth with more than 60% of the total urban population of the country [1].

The coastline is also the location of most industrial units; more than 80% of industries are located near coastal areas. The industries are highly concentrated along the Kenitra-Safi axis and especially in the Casablanca agglomeration. This axis concentrates nearly 62% of industrial units and nearly 70% of industrial employment [1].

In addition, through the marine facilities located along the coast, transiting 98% of trade with the outside of this fact Moroccan water are experiencing intense shipping. Thus, hundreds of boats run daily along the Moroccan coast, including tankers and tankers that pose a permanent threat to marine pollution. Similarly, the important fisheries resources consist of more than 7137 animal species providing a fishing potential estimated at 1000 000 annual tons [2].

In recent years, tourism policy has made seaside a priority option and this by the development of certain areas such as Tangier and Agadir which concentrate 70% of the hotel capacity approved. The surge in domestic demand on the seaside has also led to the proliferation of second home projects and the occupation of the public domain, which has led to the emergence of a real lack of health infrastructure and consequently a negative impact on several beaches.

Moreover, the quality of the beaches has become over the years a criterion increasingly used by the general public to choose its holiday beaches. This led the authorities to ensure the protection of beaches against pollution by wastewater and to establish a classification of beaches according to their quality. In 2015, 373 declared beaches suitable for bathing in Morocco.

The Main objective of our current research is to make a diagnosis of bathing water safety through physicochemical and microbiological monitoring.

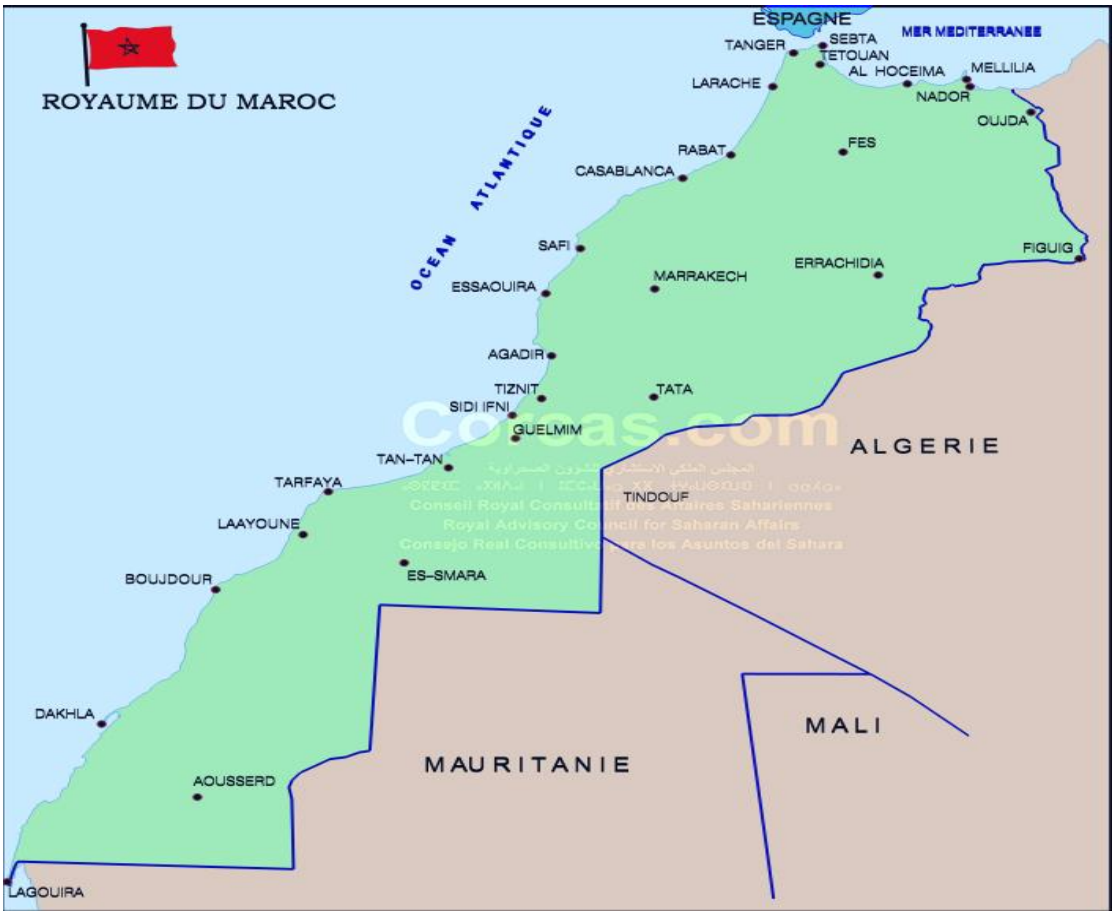

FIGURE 1: Moroccan map and geographical position of Dakhla-Oued Eddahab Bay

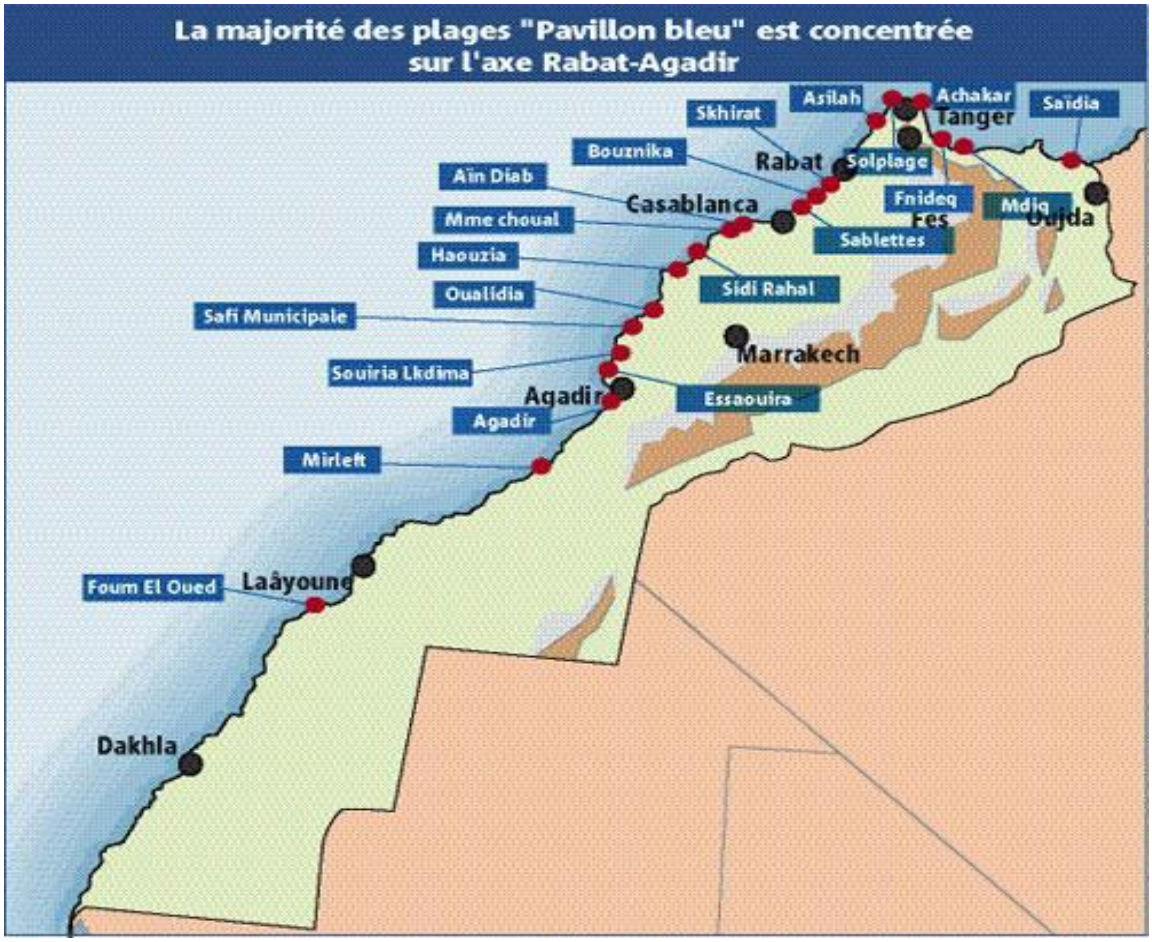

FIGURE 2: Moroccan Atlantic and Mediterranean beaches

II. MATERIAL AND METHOD

2.1 Study area

Our sampling focused on the 4 beaches of Dakhla bay: **Foum Lebouir**, **Al Moussafir**, **Tourist PK25**, and **Lakheira** Beaches (**Fig. 3**). The beaches that are the subject of our study are part of the Dakhla Oued Eddahab region which is the 12th region of Morocco. The Dakhla Oued Eddahab Region is divided into two provinces (divided into 4 circles and 13 communes including 2 urban). The region has 2 provinces: Oued Eddahab and Aousserd. The Ouad Eddahab province has an area of 76 948 km^2. With Dakhla as urban commune and 6 rural communes: El Argoub, Imlili, Bir Anzaran, Umm Dreyga, Gleibat El Foula, MIjik [**3**]. Aousserd province an area of 65,917 km^2. Lagouira is the urban municipality. 5 rural communes: Aousserd, Zug, Tichla, Aghouinite, Bir Gandouz [4].

The study area is located on the Atlantic coast, dominated by sandy beaches, rocky plateau without cliffs, small and medium cliffs, large dunes at more or less advanced stages of fixations by the flora of the sub floor. The tidal sway zone is essentially composed of very fine sand with shell debris.

Coastal marine currents are mainly induced by winds. The influence of the tide is very weak and the general current of the Canaries, south direction, is not perceptible near the coast. The study area is located in the city of Dakhla. The Dakhla Bay extends over a length of 37 km and an area of almost 400 km². The population of Wadi Eddahab in 2014 is about 126 057 inhabitants [3]. The population of Aousserd province in 2014 is 16 010 inhabitants [3].

The study area is subject to considerable urban pressure and is therefore influenced by the various urban, port and tourist activities. It receives inputs from the watersheds of Oued Eddahab region rivers and the continental alluvium they carry as well as the wastewater outfalls of coastal agglomerations and hotels.

FIGURE 3: Satellite view of the Oued Eddahab-Dakhla bay

2.1.1 Foum Labouir Beach

The beach of Foum Labouir is located on the bay of Oued Eddahab on the Atlantic coast of the urban district of Dakhla oriented NNE-SSW, about 8 km from the urban center (**Fig.4**). The beach of Foum Labouir is south of the park Foum Labouir. It is characterized by a clean concave bank with fine yellow-gray colored sands but is also the natural extension of several other natural sites such as the eco-forest park and the Tarouma farms, known for their ostrich breeding unit.

Foum Labouir is also a site to which fans and professionals of water sports converge, especially Surf and Kitsurf and where are organized several international competitions such as the Kitesurf World Cup.

This area has attracted many investors in the tourism sector and has seen the establishment of several hotel units such as the eco-lodge, West Point and other project in progress.

During each summer season, the beach "Foum Labouir" becomes a popular area for the people of Dakhla, who flock there en masse to enjoy the entertainment moments provided by its refreshing waters and golden sands.

Efforts are being made to increase the attractiveness of the city, improve its urban aesthetics, establish an architectural tradition that respects the environment, preserve the ecosystem of the bay and promote the tourist potential of the region.

In addition, the recent establishment of a new landfill, the implementation of liquid and solid sanitation projects, the development of the cornice and the coastal road, as well as green spaces have contributed to the attractiveness from the city and its beaches.

In addition to these achievements, other projects have been launched in recent months, including the development of public squares and green spaces as well as the renovation of the public lighting of the "Al Oualaa" avenue.

At the level of "Foum Labouir", the various measures taken in terms of environmental protection have made it possible to improve the cleanliness of the beach and the summering conditions and to create spaces dedicated to people with specific needs.

2.1.2 Beach of El Moussafir

The beach of Camping Moussafir is located on a creek on the right bank of the Wadi Eddahab bay. The beach is oriented NNE-SSW, about 7 km from the center of the city of Dakhla and the east side of the beach of Foum Labouir.

It is a beach labeled Blue Flag, clean with fine sands, color between pale yellow to white. And she is on the road that connects the city of Dakhla to Boujdour. The bathing area is characterized by calm waters and is equipped with umbrellas, and a pedestrian crossing at the seaside (**Fig.5**).

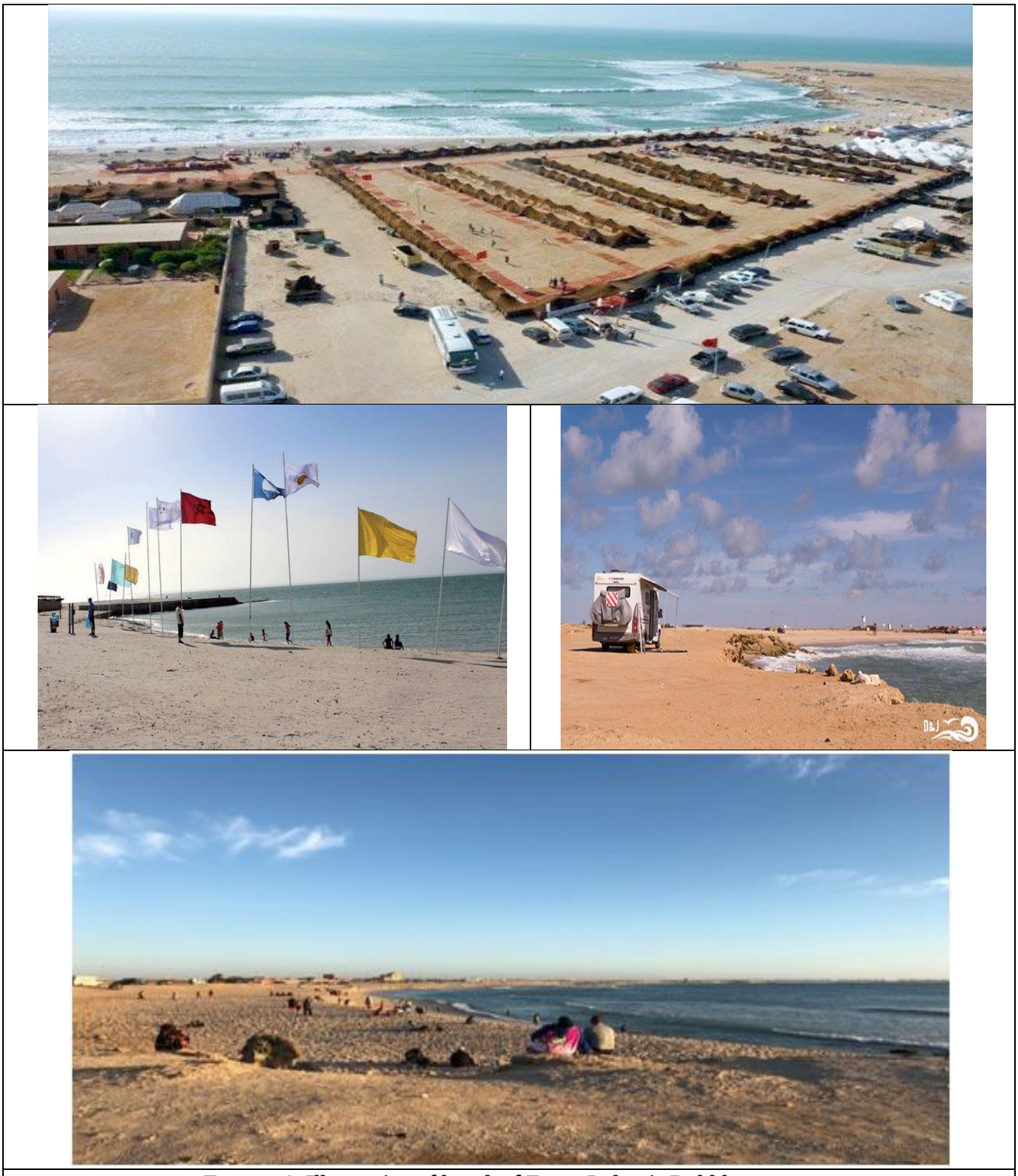

FIGURE 4: Illustration of beach of Foum Labouir Dakhla

FIGURE 5: Beach of El Moussafir (Dakhla)

2.1.3 Beach Lakheira

The LaKheira beach is a small beach in Dakhla. This beach is open on sea but receive é wastewaters collectors (**Fig.6**).

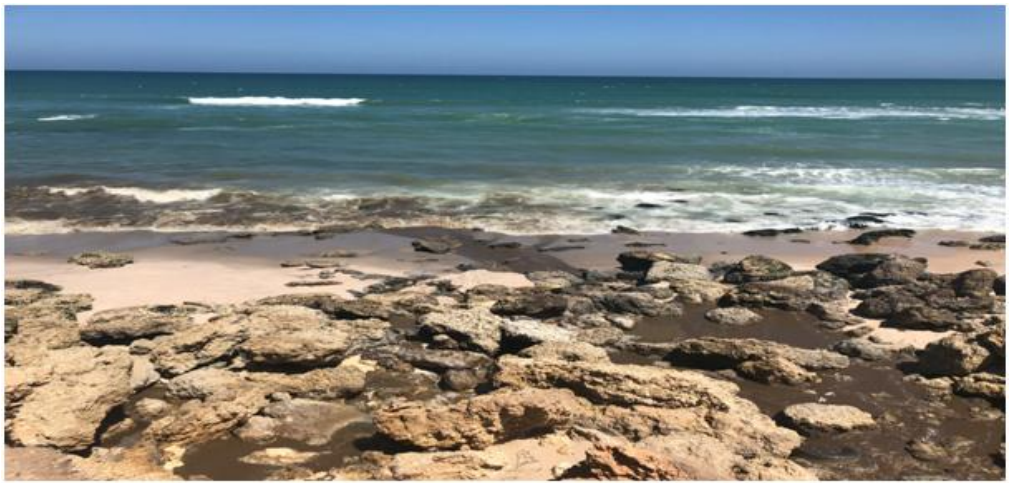

FIGURE 6: Playa Lakheira Dakhla.

2.1.4 Tourist PK25 Beach

The tourist area of Dakhla is located, northwest of the bay of Oued Eddahab. It is one of the best spot of the world to practice the Kite Surf. It is a clean beach, these sands have very fine granulometry, yellow color. It is located at 25 km from the city of Dakhla (**Fig.7**).

III. STUDY METHOD

3.1 Waters sampling

In sampling for a microbiological study, special precautions are needed to avoid contamination. For an optimal sampling one followed the Moroccan norm NM03.07.006. In our sampling we proceeded as follows (**Fig. 8**):

- sampling points are based on the extent of the beach in areas with the highest density of bathers;
- sampling at the level of the upper layer of the body of water at a depth of 30 cm;
- sampling frequency is two samples per month during the summer season and one per month for the rest of the year;
- the sampling time is fixed between 12h and 13h;
- the storage conditions of the samples designated for bacteriological analysis include storage in an insulated box at a temperature between 0 and 4 °C.

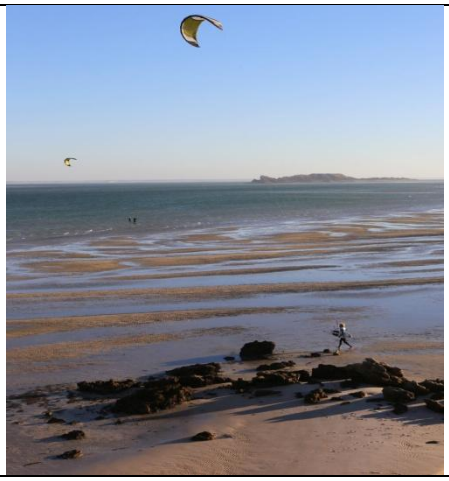

FIGURE 7: Illustration of the beach of Area Touristic PK25

In addition to the water sampling, the following parameters were measured "in situ":

+ temperature of the air using a mercury thermometer;

+ water temperature using a pH meter;

+ pH of the water using portable pH meter Hanna type Instrument;

+ tide level (high or low);

+ estimate of the bathers and swimming population.

FIGURE 8: Water sampling and microbial analysis

3.2 Microbiological analysis methods

For the prospecting of the biological quality of bathing waters, it is necessary to carry out bacteriological analyzes to search for microorganisms which are indicators of faecal pollution, especially faecal coliforms and faecal streptococci.

3.2.1 Coliforms

The term "coliform" refers to the different species belonging to the gram negative Enterobacteriaceae family, aerobic or optionally anaerobic, non-sporogonal and whose Main characteristic is the fermentation of lactose with gas production [**6**].

*** Fecal coliforms (CF).**

According to the World Health Organization [**7**], the faecal coliforms are Gram-, aerobic and facultative anaerobic, rod-shaped, non-sporulating bacteria that ferment lactose by producing gas, within 24 hours, at the same time they growth at 44°C on the medium Tergitol 7 Agar. Faecal coliforms have a highly significant positive correlation with faecal contamination caused by humans or warm-blooded animals, and are therefore a good indicator of the health quality of coastal waters [**8**]. This is based on the fact that *Echerichia coli* can't survive for a long time in the environment. Its survival time depends on several physicochemical factors, temperature is the essential factor that affects its concentration. Other work [**9**], show that the density of faecal coliforms and directly proportional to the biological oxygen demand (BOD_5). So their presence in the water always indicates a recent faecal contamination.

*** Fecal Streptococci (SF).**

Faecal Streptococci are slightly oval, Gram-positive, spherical cocci in the form of pairs or short chains during their growth on Slanetz and Bartely medium containing 2,3,5 triphenyl tetrazolium chloride (TTC).

The group of fecal streptococci normally comes from human intestines or warm-blooded animals and indicates faecal pollution when they are detected in seawater. Their mortality rate depends on salinity, temperature and solar radiation,...etc.

3.2.2 Enumeration of Fecal Coliforms

*** Filter membrane method**

The membrane filter method is the method used for the enumeration of fecal coliforms and fecal streptococci. This method is suitable for the enumeration of faecal coliforms and faecal streptococci in coastal bathing waters of temperate seas. It has been established for sanitary surveillance of beaches [**10-13**].

- **Principle:**

The method consists in filtering a volume of seawater sample taken under sterile conditions, according to the quantity of coliforms estimated in the water sample. The filtration membrane should have a pore diameter of 0.45 µm optimal for the total retention of bacteria. The membrane is placed on the surface of the culture medium poured into Petri dishes and cultured. After incubation the cultures are examined for bacterial colonies with specific characteristics and count to deduce the bacterial concentration per 100 ml of water (**Fig.9**).

- **Interpretation:**

Sodium heptadecyl sulfate (Tergitol 7) inhibits unwanted secondary flora. The degradation of lactose to acid is revealed by a yellow turn of the pH indicator, bromothymol blue, biphenyl chloride 2,3,5 tetrazolium (TTC) is reduced very rapidly by almost all coliforms except *Escherichia coli* and *Enterobacter aerogens* which give a red coloring.

Yellow colonies with yellow halo ⟶ *Escherichia coli*

Red with possibly yellow halo ⟶ Coliforms without *E. coli*

- **Confirmatory test**:

Faecal coliform colonies presumed on Tergitol 7 Agar medium are confirmed on bright green bilious lactose medium at 37 ± 1 °C for 24-48h.

- **Interpretation**:

Cloudy medium and presence of gas under the bell ⟶ Fermentation of lactose ⟶ Coliforms.

FIGURE 9: Bacterial culture

3.2.3 Enumeration of Fecal Streptococci

For Enterococci on membrane filters, selective Agar is used according to Slanetz and Bartley. This medium contains an abundant amount of nutrients to ensure good growth. On the other hand, all secondary flora is inhibited by azide.

- **Interpretation:**

Enterococci colonies reduce TTC to red-colored formazan, which allows early identification of yellow Escherichia coli colonies.

Pink to brown colonies with a diameter of 0.5 to 2 mm are usually fecal streptococci.

- **Confirmatory test:**

Fecal Streptococci colonies presumed on Slanetz & Bartley medium are confirmed on Litskey medium at 37 ± 1 ° C for 24-48h. Tubes with a disorder are considered positive and taken into account for the enumeration of fecal streptococci.

3.3 Method of classification of bathing waters

For the classification of bathing waters four categories are distinguished namely: **A**, **B**, **C** and **D** on the basis of the overrun of the Moroccan standards [**1**] for monitoring the quality of bathing water (**Tab.1**) and the international standards and guidelines for the sanitary monitoring of bathing waters [**14-15**].

TABLE 1
GUIDE VALUES AND IMPERATIVE VALUES SET BY THE MOROCCAN STANDARD NM 03.7.200 [1].

Parameters	Guide Value VG UFC/100mL	Imperative Value VI UFC/100mL
Fecal Coliforms	100	2000
Fecal Streptococci	100	400

*** Category A**: Good quality waters for swimming.

- At least 80% of Escherichia coli or faecal coliform results are less than or equal to the guideline value of 100 bacteria / 100mL;
- At least 95% of the results in E. coli or faecal coliforms are less than or equal to the mandatory value of 2000 bacteria / 100 mL;
- At least 90% of fecal Streptococci results are less than or equal to the guideline value of 100 bacteria / 100 mL.

* **Category B**: Medium quality waters for swimming.

- The water quality is medium when the imperative number set by the directive for E. coli and faecal coliforms of 2000 CFU / 100mL is respected in less than 95% of the samples.

* **Category C**: Waters temporarily polluted.

- Water monitoring points for which the frequency of exceeding the mandatory number for E. coli or faecal coliforms is between 5% and 33.3% is considered to be temporarily polluted. This pollution can be the subject of immediate or medium-term measures to permanently improve the quality of water.
- It is important to note that if less than 20 samples are taken during the whole season on one point, a single exceeding of the imperative number in E. coli or faecal coliforms, is enough to cause the classification of the beach in category C.

* **Category D**: Poor quality waters.

- Where, for the E. coli or faecal coliform parameter, the conditions relating to the imperative number are exceeded at least once in three, the bathing water concerned is considered to be of poor quality. All areas classified as Category D for two consecutive years shall be prohibited from swimming unless significant improvements occur.

Waters classified in categories **A** or **B** comply with the bathing standard, however, waters classified in categories **C** or **D** do not comply with the standard.

IV. RESULTS AND DISCUSSION

During our surveillance mission, several bathing water samples were taken at the Main beaches of the region Oued Eddahab-Dakhla Bay. Monitoring includes bi-monthly beaches visits, climate surveys, physicochemical measurements and microbiological analyzes (faecal coliforms, faecal streptococci and *Escherichia coli*).

The Main results of the analyzed parameters "in situ" and the microbiology laboratory of the National Institute of Fisheries Research Dakhla (**INRH**) are summarized in Figures 10-14 and Tables 2 to 10.

4.1 In the Al Moussafir beach,

The population of bathers or swimming increase from 2015 to 2017. The maximum of beach visitors are observed in the months of July and August (=700 persons) (Figure 10). The increase of temperature is also favorable for swimming (Figure

In our monitoring of the bacterial load of beaches, it has been found that this beach must be classified **A** because of:

*the contamination standard is exceeded only in 27% of samples for Fecal coliforms and only in 2017 (**Fig. 11**);

*the Fecal Streptococci is exceeded only in 18% of samples in 2016 and 2017 (**Fig. 12**);

*the contamination standard by *Escherichia coli* never exceeded the standard of samples in 2015-2017 (**Fig. 13**);

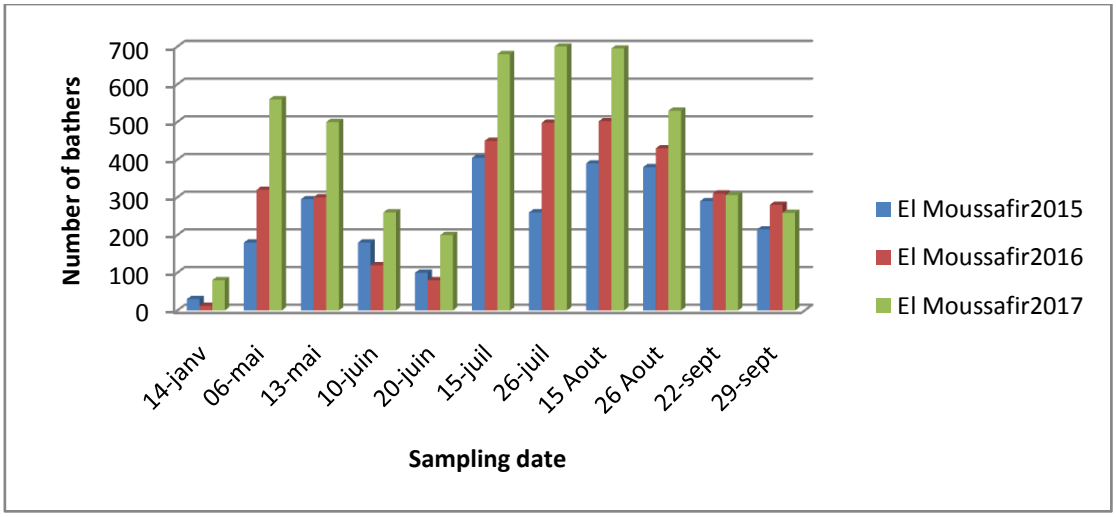

FIGURE 10: Monthly variation of bathers in Al Moussafir beach during years 2015-2017

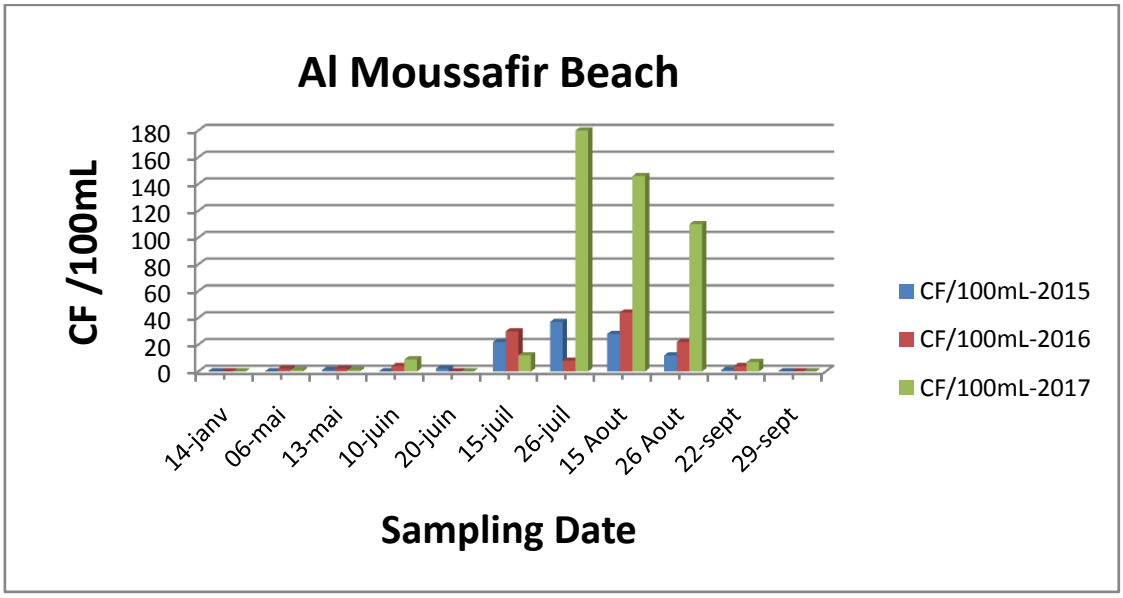

FIGURE 11 : Monthly variation of Fecal Coliforms in Al Moussafir beach during years 2015-2017

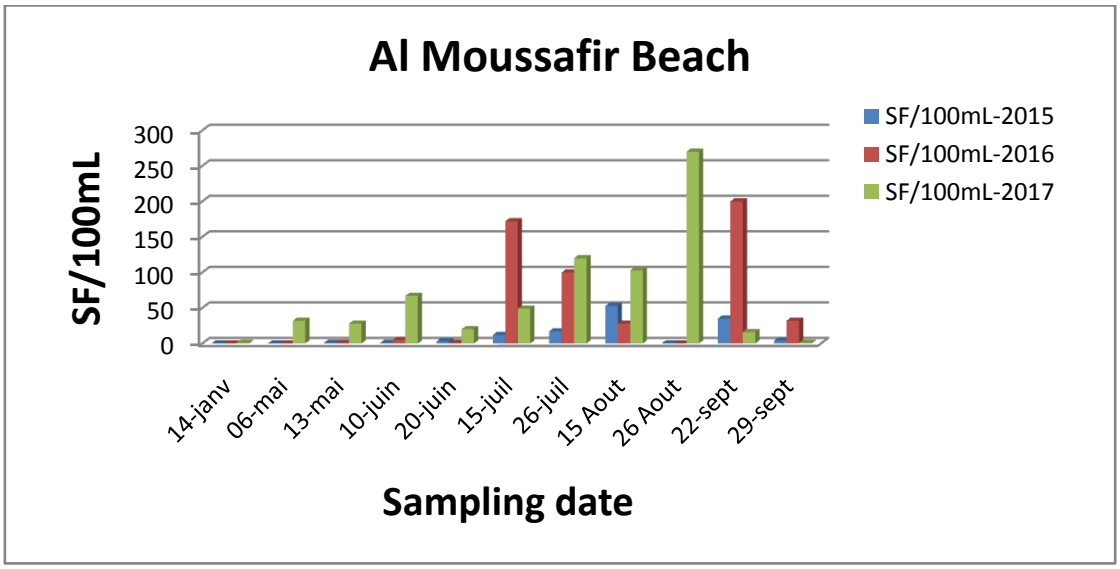

FIGURE 12 : Monthly variation of Fecal Steroptococci in Al Moussafir beach during years 2015-2017

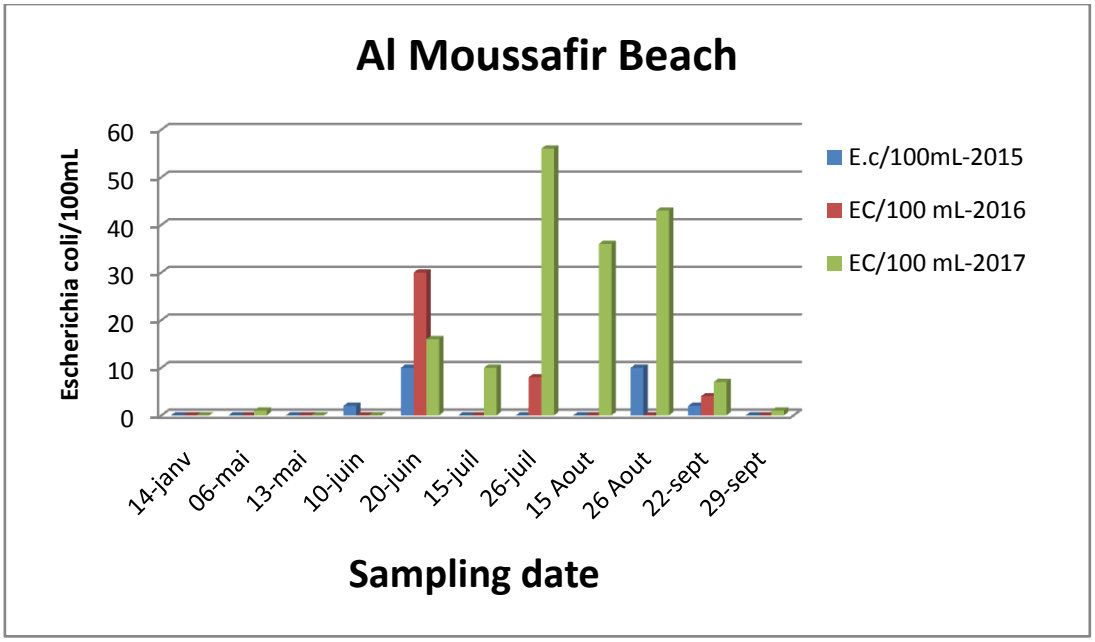

FIGURE 13 : Monthly variation of *Escherichia coli* in Al Moussafir beach during years 2015-2017

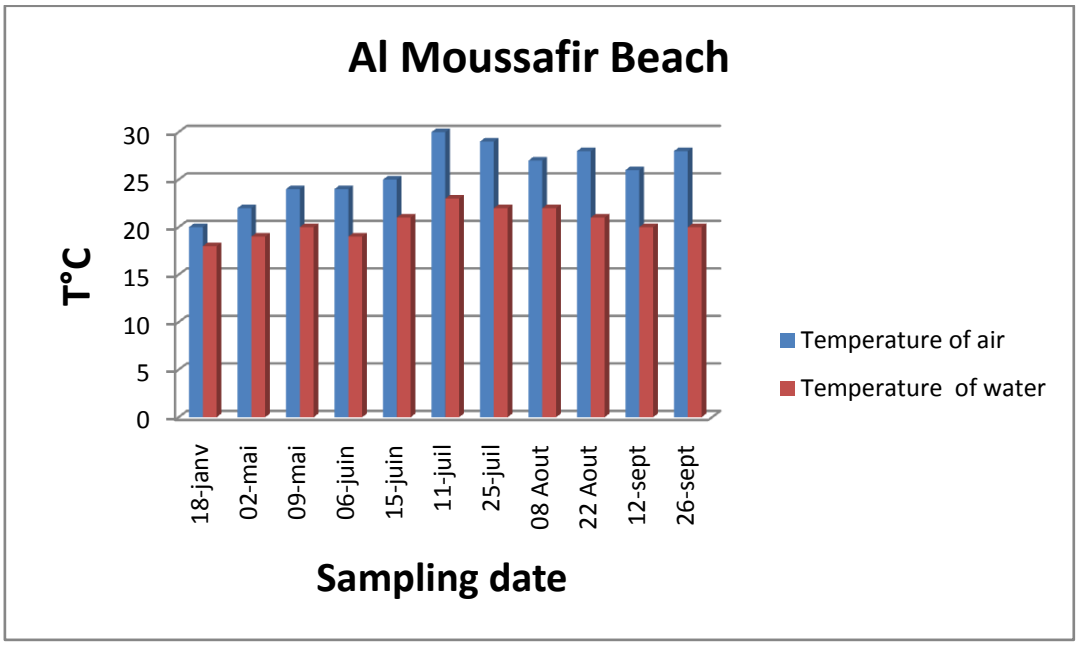

FIGURE 14 : Monthly variation of temperature in Al Moussafir beach during years 2015.

4.2 In the Foum Lebouir beach

The population of bathers or swimming increase from 2015 to 2017 beginning with 80 bathers in 2015. The maximum of beach visitors are observed in the months of July and August (=850 persons) (**Tab. 2-4**).

In our monitoring of the bacterial load of beaches, it has been found that this beach must be classified **A** in 2015 and 2016 but must be degraded to rank **B** in 2017 because of:

* the contamination standard is exceeded in 30% for faecal coliform samples as of 2017 (**Tab. 4**);

4.3 In the LaKheira beach,

The population of bathers or swimming increase from 2015 to 2017 beginning with 12 bathers in 2015. The maximum of beach visitors are observed in the months of July and August (=358 persons) (**Tab. 5-7**).

In our monitoring of the bacterial load of beaches, it has been found that this beach must be classified **A** in 2015 because of:

* the contamination standard not exceeded in 9% for faecal coliform samples in 2015 (**Tab. 5**);

* the contamination standard not exceeded in 9% for faecal streptococci samples in 2015 (**Tab. 5**);

* the standard of *Escherichia coli* contamination was exceeded in none of the samples (0%) in 2015 (**Tab. 5**);

In our monitoring of the bacterial load of beaches, it has been found that this beach must be classified **B** in 2016 because of:

* the contamination standard exceeded in 64% for faecal coliform samples in 2016 (**Tab. 6**);

* the contamination standard exceeded in 64% for faecal streptococci samples (**Tab. 6**);

* the contamination exceeded imperative value (>400 UFC/100mL) for Streptococci but not for coliforms (<2000UFC/100mL) in 2016;

In our monitoring of the bacterial load of beaches, it has been found that this beach must be classified **C** in 2017 because of:

* the contamination standard exceeded in 100% for faecal coliform samples in 2017 (**Tab. 7**);

* the contamination standard exceeded in 91% for faecal streptococci samples (**Tab. 7**);

* the contamination exceeded imperative value (>2000 UFC/100mL) in 1 from 11 samples in 2017 (**Tab.7**);

The relatively high percentages of exceedance for faecal coliform guideline values were recorded at the beaches of Lakheira, with over 64% exceedance (**Tab. 5-7**). The highest percentages of contamination not faecal coliforms and streptococci increase with years. This highest level were correlated to increase of wastewaters from 2015 to 2017 by addition of new agro industry (canning fish) (**Fig. 15**).

TABLE 2
MONTHLY VARIATION OF BACTERIAL CONTAMINATION OF FOUM LEBOUIR BEACH (2015).

Date 2015	Temperature		Tide	Bathers	CF/100mL	SF/100mL	E.C/100mL
	Air	Water					
18-January	20	18	High	16	1	0	0
02-May	22	18	High	55	70	0	0
09-May	24	18,5	Low	64	76	0	0
06-June	24	18	High	70	68	0	0
15-June	25	20	Low	30	0	15	0
11-July	30	24	Low	78	36	10	4
25-July	29	24	High	80	40	17	2
08-August	27	20	Low	90	14	12	0
22-August	28	21	Low	90	8	46	15
12-September	26	20	High	35	0	12	0
26- September	28	20	Low	28	2	3	0

TABLE 3
MONTHLY VARIATION OF BACTERIAL CONTAMINATION OF FOUM LEBOUIR BEACH (2016).

Date 2016	Temperature		Tide	Bathers	CF/100mL	SF/100mL	EI/100 mL
	Air	Water					
26-January	22	19	High	35	0	1	0
07-May	23	19,5	High	90	70	0	0
14-May	22	19	Low	96	76	0	0
16-June	24	18	High	40	68	1	0
22-June	29	19	Low	60	72	5	0
16-July	32	24	Low	199	56	11	14
25-July	30	24	High	180	51	17	0
06 August	28	20	Low	170	60	190	0
25 August	27	20	Low	160	41	52	0
09-September	26	20	Low	105	4	104	14
23-September	27	20	High	90	4	40	0

TABLE 4
MONTHLY VARIATION OF BACTERIOLOGICAL AND PHYSICO-CHEMICAL OF FOUM LEBOUIR BEACH (2017)

Date 2017	Temperature		Tide	Bathers	CF/100mL	SF/100mL	EC/100mL
	Air	Water					
14-January	20	19	High	70	5	0	0
06-May	22	18	Low	350	10	0	0
13-May	22	19	High	320	12	0	0
10-June	26	20	High	220	50	3	1
20-June	26	21	Low	200	117	40	15
15-July	25	19	High	430	72	9	3
26-July	26	20	Low	460	26	6	1
15 August	30	24	High	700	202	2	0
26 August	23	22	High	850	165	195	12
22-September	22	20	High	580	23	29	3
29-September	24	20	Low	440	12	14	2

TABLE 5
MONTHLY VARIATION IN BACTERIAL CONTAMINATION OF THE LAKHEIRA BEACH (2015).

Date 2015	Temperature		Tide	Bathers	CF/100mL	SF/100mL	CF/100mL
	Air	Water					
18-January	20	18	High	12	50	32	3
02-May	22	18,5	High	120	80	57	10
09-May	24	18	Low	190	70	63	52
06-June	24	19	High	140	103	72	18
15-June	25	20	Low	50	75	82	0
11-July	30	23,5	Low	70	89	67	18
25-July	29	24	High	240	81	90	30
08 August	27	20	Low	248	99	67	0
22August	28	22	Low	257	56	120	19
12-September	26	20	High	180	60	32	2
26-September	28	20	Low	188	45	16	0

TABLE 6
MONTHLY VARIATION IN BACTERIAL CONTAMINATION OF THE LAKHEIRA BEACH (2016)

Date 2016	Temperature		Tide	Bathers	CF/100mL	SF/100mL	EC /100mL
	Air	Water					
26-January	20	18	High	30	90	56	12
07-May	23	20	High	170	120	96	0
14-May	22	19	Low	210	320	76	210
16-June	24	19	High	80	140	118	0
22-June	29	20	Low	110	98	108	44
16-July	32	23,5	Low	299	580	460	13
25-July	30	25	High	250	41	207	30
06 August	28	21	Low	260	120	118	70
25 August	27	20	Low	230	180	360	0
09-September	26	21	Low	120	90	44	16
23-September	27	18	High	90	152	400	10

TABLE 7
MONTHLY VARIATION IN BACTERIAL CONTAMINATION OF THE LAKHEIRA BEACH (2017)

Date 2017	Temperature		Tide	Bathers	CF/100mL	SF/100mL	EC/100 mL
	Air	Water					
17-January	20	19	High	45	210	60	24
06-May	22	19	Low	240	140	120	12
13-May	22	19	High	300	326	110	56
10-June	26	21	High	180	410	136	60
20-June	26	21	Law	120	>2000	350	230
15-July	25	19.5	High	340	256	184	30
26-July	26	21	Law	358	461	280	18
15 August	30	23	High	320	390	190	83
26 August	23	22	High	280	156	196	42
22-September	22	20	High	120	340	370	38
29-September	24	20	Law	98	180	347	180

FIGURE 15: Spreading of raw sewage on Lakheira beach

4.4 In the Tourist PK25 beach

The population of bathers or swimming strongly increase from 2015 to 2017. The maximum of beach visitors are observed in the months of July and August (=1400 bathers) (**Tab.8-10**).

In our monitoring of the bacterial load of beaches, it has been found that this beach must be classified **A** because of:

*the contamination standard is exceeded only in 9% of samples for Fecal coliforms and only in 2015 (**Tab.8-10**);

*the Fecal Streptococci is exceeded only in 18% of samples only in 2015 (**Tab.8-10**);

*the contamination standard by *Escherichia coli* never exceeded the standard of samples in 2015-2017 (**Tab.8-10**);

TABLE 8
MONTHLY VARIATION IN BACTERIAL CONTAMINATION OF THE TOURIST BEACH PK 25 (2015)

Date 2015	Temperature		Tide	Bathers	CF/100mL	SF/100mL	EC/100 mL
	Air	Water					
18-January	20	18	High	480	15	0	0
02-May	21	19	High	665	66	10	0
09-May	23	20	Low	447	73	13	0
06-June	23	19	High	480	54	90	2
15-June	24	21	Low	345	67	131	23
11-July	28	25	Low	367	171	112	12
25-July	28	25	High	388	57	34	0
08 August	26	22	Low	557	87	32	2
22 August	28	21	Low	630	38	12	0
12-September	26	20	High	450	19	4	9
26-September	28	20	Low	510	23	11	1

TABLE 9
MONTHLY VARIATION IN BACTERIAL CONTAMINATION OF THE TOURISTIC BEACH PK 25-28 (2016)

Date 2016	Temperature		Tide	Bathers	CF/100mL	SF/100mL	EC/100mL
	Air	Water					
26-January	20	19	High	420	0	0	0
07-May	22	20	High	768	12	0	0
14-May	21,5	19,5	Law	690	35	3	1
16-June	23	20	High	580	65	24	8
22-June	28	21	Law	470	44	5	0
16-July	31	24,5	Law	664	56	11	4
25-July	29	22	High	980	72	70	6
06 August	27,5	21	Low	788	47	3	0
25 August	28	21	Low	680	0	15	0
12-September	26	20	High	520	12	18	8
26-September	28	20	Law	610	36	56	7

TABLE 10
MONTHLY VARIATION IN BACTERIAL CONTAMINATION OF THE PK 25S BEACH (2017).

Date 2017	Temperature		Tide	Bathers	CF/100mL	SF/100mL	EC/100mL
	Air	Water					
07-January	20	19	High	890	1	0	0
06-May	21,5	19	Law	1010	13	7	0
13-May	21	19,5	High	800	17	1	0
10-June	26	21	High	1100	24	13	1
20-June	25	21	Law	980	9	1	0
15-July	24	19,5	High	1050	65	36	9
26-July	25,5	21	Law	970	70	50	26
15 August	29	24	High	1400	12	3	0
26 August	23	22	High	1350	60	19	12
22-September	22	20	High	1100	58	27	20
29-September	24	20	Law	1200	15	8	1

V. CONCLUSION

The assessment of the quality of the beaches that were monitored during the 2015 to 2017 surveys based on the Moroccan standard NM 03.7.200 (**Tab.1**) and the classification grid made it possible to list the clean beaches and the beaches. improper ranges and prioritize them as follows:

- The beache of **Al Moussafir** is classified **A** in all years 2015 to 2017;
- The beache of **Foum Lebouir** is classified **A** in 2015 and **B** in 2017;
- The beach of Tourist PK beach is classified **A** in all years 2015 to 2017;
- Unfortunately, the Lakheira beach deteriorates from class **A** to **B** then to **C** between 2015 and 2017. This decline was attributed to the increase in the number of tourists and the raw sewage flows discharged directly to the beach level.

In addition, the annual evolution of beach safety has shown a significant increase in bacterial contamination during the summer period, which begins in May-June. The highest infections are noted in July and August and decrease in spring and winter. This variation in the level of contamination is explained by the following facts:

- The beginning of the seaside activity by the occupation of the secondary houses at the edge of the beaches and the swimming start at the end of May;
- The school holidays in July August coincide with the maximum contaminations;
- The increase in the number of summer visitors in coastal cities, which has an impact on pollution flows from coastal emissions;
- Increased flow of tourists and Moroccans living abroad.

Observations made in the field during the summer have shown that the density of summer visitors is maximum in the afternoon, it is even more during the weekend (**Table 2-10**). The flow of holidaymakers reaches its peak especially during the months of July and August; period when all homes, hotels and inns are over-saturated.

The waters sampled at the beaches of Foum Lebouir and Lakheira are of average quality for bathing because of a more pronounced contamination by the indicator germs of fecal contamination. This pollution and degradation of the environment are mainly related to the activities of summer visitors during the summer. The temperature and pH of water are favorable for the survival of bacteria (**Table 2-10**).

This contamination is aggravated by the lack of infrastructure (garbage cans, toilets, showers, signs, etc.), the lack of liquid sanitation networks and the use of septic tanks and poor solid waste management.

Lakheira beach has an poor quality for swimming. It is a special ecosystem due to the presence of agro industry unit which reject rough wastewaters. In fact, the pollution generated is very impressive because of the tourists and industrial activities.

In fact, the sewage as soon as they arrive in the rivers is diluted by the rains. Similarly, domestic pollution is dampened by industrial and agricultural waste rich in heavy metals and pesticides that prevent the proliferation of microorganisms due to bacterial inhibition by toxicity and eutrophication.

The beaches of the **Al Moussafir** and **Tourist PK25** are of good quality for swimming due to the absence of wastewater discharges and also the low pressure of pollution.

In conclusion of our study it appears that the efforts made by the Moroccan government to preserve the environmental quality of beaches must be reinforced by:

- activation of the establishment of wastewater treatment plants and the necessary and adequate sanitation systems, both for solid discharges and for liquid discharges in coastal cities;
- put in place and implement the legislative and regulatory measures necessary to preserve the coastline, notably through the activation of the enactment of the law on the protection of the coastline;
- ensure compliance with the provisions of the regulatory texts governing standards for direct and indirect discharges of wastewater;
- create a national institution responsible for coastal zone management;
- endow the shoreline with master plans and beaches with development plans for recreation, hygiene and safety infrastructures;
- provide the ports with the necessary means of decontamination;
- strengthen the beaches in material and human resources for safety, hygiene and cleaning.

ACKNOWLEDGEMENTS

The authors acknowledge the National Institute of Fisheries Research Dakhla who allowed this bacteriological monitoring.

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