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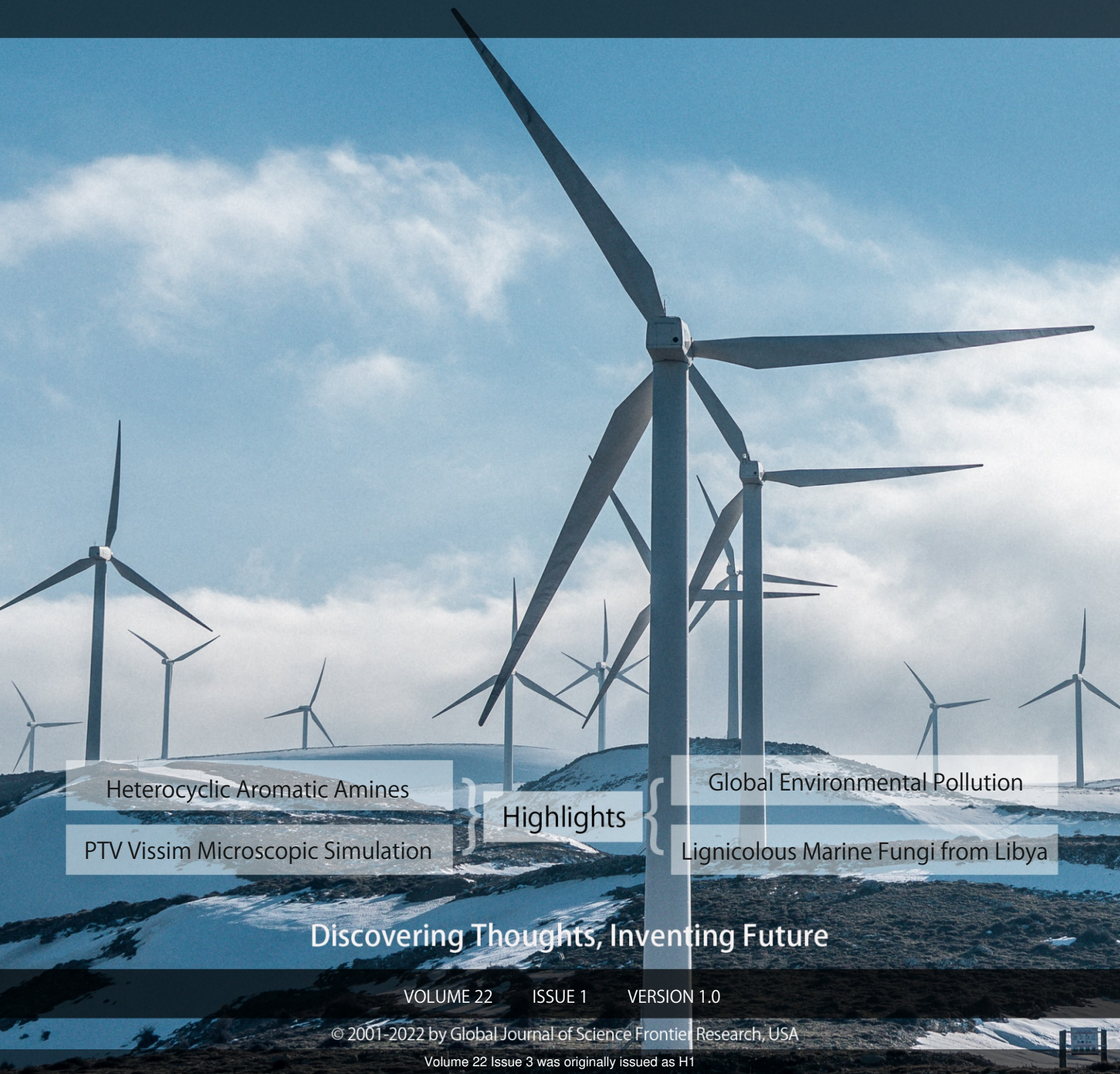

Heterocyclic Aromatic Amines

PTV Vissim Microscopic Simulation

Highlights

Global Environmental Pollution

Lignicolous Marine Fungi from Libya

Discovering Thoughts, Inventing Future

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Ways to Reduce the Amount of Heterocyclic Aromatic Amines Formed in Meat Products. The Review

By Dmitry A. Utyanov, Andrey V. Kulikovskii, Alexandra S. Knyazeva & Anastasia A. Kurzova

V.M. Gorbatov Federal Research Center for Food Systems of Russian Academy of Sciences

Abstract- This review presents the results of studies on the issue of reducing the amount of heterocyclic aromatic amines formed in meat products. The analyzed works have shown that it is possible to influence the amount of heterocyclic aromatic amines through their precursors, heat treatment of meat products, and the introduction of non-meat ingredients into the recipe. An analysis of works devoted to the effect of temperature and duration of heat treatment on the amount of heterocyclic aromatic amines formed is presented. As a result of the analysis, it was found that free amino acids, moisture, and the water-holding capacity of the raw material play an essetial role in the formation of heterocyclic aromatic amines. Many analyzed works proved the inhibitory effect of vitamin E in the formation of heterocyclic aromatic amines. Inhibitory effects of pomegranate seed extract, artichoke extract are described. The impact of replacing animal fat with vegetable oils on the amount of heterocyclic aromatic amines formed is described.

Keywords: heterocyclic aromatic amines, meat products, inhibitors, precursors, catalysts, heat treatment, extracts, antioxidant activity.

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Ways to Reduce the Amount of Heterocyclic Aromatic Amines Formed in Meat Products the Review

Dmitry A. Utyanov [α], Andrey V. Kulikovskii [σ], Alexandra S. Knyazeva [ρ] & Anastasia A. Kurzova [ω]

Abstract- This review presents the results of studies on the issue of reducing the amount of heterocyclic aromatic amines formed in meat products. The analyzed works have shown that it is possible to influence the amount of heterocyclic aromatic amines through their precursors, heat treatment of meat products, and the introduction of non-meat ingredients into the recipe. An analysis of works devoted to the effect of temperature and duration of heat treatment on the amount of heterocyclic aromatic amines formed is presented. As a result of the analysis, it was found that free amino acids, moisture, and the water-holding capacity of the raw material play an essetial role in the formation of heterocyclic aromatic amines. Many analyzed works proved the inhibitory effect of vitamin E in the formation of heterocyclic aromatic amines. Inhibitory effects of pomegranate seed extract, artichoke extract are described. The impact of replacing animal fat with vegetable oils on the amount of heterocyclic aromatic amines formed is described.

Keywords: heterocyclic aromatic amines, meat products, inhibitors, precursors, catalysts, heat treatment, extracts, antioxidant activity.

Abbreviations

HAA - heterocyclic aromatic amines
IQ - 2-amino-3-methyl-imidazo[4,5-f]-quinoline
IQx - 2-amino-3-methyl-imidazo[4,5-f]-quinoxaline
MeIQ - 2-amino-3,4-dimethyl-imidazo[4,5-b]-quinoline
DiMeIQx - 2-amino-3,4,8-trimethyl-imidazo[4,5-f]-quinoxaline
PhIP- 2-amino-1-methyl-6-phenylimidazo[4,5-b]-pyridine
n/d - not detected

Author α: Cand. Sci. (Eng.), Researcher of the Laboratory for Scientific and Methodological Works, Biological and Analytical Research, V.M. Gorbatov Federal Research Center for Food Systems of Russian Academy of Sciences, Russian Federation, Moscow, Talalikhinast., 26. e-mail: d.utyanov@fncps.ru
Author σ: Cand. Sci. (Eng.), Head of the Laboratory for Scientific and Methodological Works, Biological and Analytical Research, V.M. Gorbatov Federal Research Center for Food Systems of Russian Academy of Sciences, Russian Federation, 109316, Moscow, Talalikhinast., 26. e-mail: a.kulikovskii@fncps.ru
Author ρ ω: Junior researcher of the Laboratory for Scientific and Methodological Works, Biological and Analytical Research, V.M. Gorbatov Federal Research Center for Food Systems of Russian Academy of Sciences, Russian Federation, 109316, Moscow, Talalikhinast., 26. e-mails: a.knyazeva@fncps.ru, a.kurzova@fncps.ru

I. Introduction

During the heat treatment of meat products, due to its complex chemical composition, a large number of new chemical compounds are formed. Often, these compounds have carcinogenic and mutagenic activity. These carcinogens include HAA, which are formed in meat products during its high-temperature heat treatment as products of the Maillard reaction. The carcinogenic and mutagenic potential of HAA has been proven by many works on laboratory animals and protozoa [1-3]. Consumption of products with HAA is associated with the occurrence of cancer in humans, precisely with cancer of the gastrointestinal tract [4-6].

Considering the potential danger of HAA, it is necessary to find ways to reduce their formation in meat products during heat treatment. This paper is the review of articles that present studies on reducing the amount of HAA. Based on the analysis, it was found that a decrease in the amount of HAA formed in the product is possible in the following ways:

– impact on HAA precursors;
– changing cooking modes;
– changing recipes.

II. Main Part

a) Precursors

Since the amino-imidazoarenes group is formed during the Maillard reaction, the most obvious way to influence their quantity is to impacton amino acids, creatine/creatinine and carbohydrates in the raw material.

It has been established that sugars are one of the main precursors in the formation of HAA. Sugars have been established to be inhibitors in the reaction of HAA formation [7]. In [8], the impact of mono- and disaccharides on the amount of HAA formed was studied. Catalytic effect of mono- and disaccharides have been found in cases when the amount of sugars involved in the reaction are less than creatine/creatinine, but in cases when there are more sugars than creatine/creatinine, they have a strong inhibitory effect. This is due to the fact that during the Maillard reaction from sugars, with their excess, 5-hydroxymethyl-2-

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furfural is formed, which simultaneously reduces the amount of HAA formed, because of its reaction with creatine/creatinine. Thus, in [9], honey, a rich source of glucose and fructose, have been found as the most effective among all sources of low molecular weight carbohydrates in terms of reducing the amount of HAA.

Amino acids, especially unbound amino acids, play a significant role in the formation of HAA since they more easily enter into the reaction of formation of HAA than the bounded in protein amino acids. In [10], a summary of the effect of unbound amino acids on the formation of aminoimidazoarenes is given.

The moisture content and water holding capacity of the raw material also affect the amount of HAA formed since moisture acts as a carrier of precursors in the HAA formation reaction, delivering them from the middle of the product to the surface [7].

The fat content of the product also plays a role in the formation of HAA. In [11], it was found that a lower fat content in raw materials leads to a larger amount of HAAs formed. This may be due to the fact that fat, being a good heat carrier, leads to faster cooking of the product, which reduces the amount of HAA in the finished product.

b) Heat treatment mode

Perhaps the greatest number of works on the issue of HAA formation is devoted to the influence of the heat treatment method. The main provisions established in these works are that the processing temperature should be above 150 C, and the longer the heat treatment process lasts, the greater the amount of HAA is formed. Accordingly, during heat treatment such as frying, grilling/barbecuing, and baking, the tremendous amount of HAA is formed. In [12], it was found that an increase in the duration of heat treatment of a meat lump semi-finished product by 2.5 minutes on each side leads to an increase in the amount of HAA by 1.5 times. It was found in [13] that an increase in the duration of heat treatment of chopped semi-finished products by 4 minutes on each side at temperatures from 175°C to 225°C increases the amount of HAA by 2-5 times. The most obvious way to reduce the amount of HAA, in this case, is to reduce the temperature and duration of heat treatment of the product. Still, in this case, the organoleptic properties of the product deteriorate.

The prethermal processing by microwave radiation has been noted as the way to reduce the amount of HAA formed during further heat treatment. Studies [14] found that the processing of raw materials in a microwave oven before heat treatment for two minutes leads to a decrease in the amount of PhIP up to 86%.

Another method that can reduce the amount of HAA formed is breading the product. However, the breading must be thick enough to do this. Currently, there are not so many works in this area, which indicates the need for research in this direction, given that breading is a relatively common method of technological processing of raw materials.

c) Recipe changes

Recipes changes are perhaps the simplest and most effective way to influence the amount of HAA produced. Prethermal processing of meat raw materials with ingredients with an established inhibitory effect in the formation of HAA can lead to a significant decrease in their amount. The greatest reduction in the amount of HAA can be achieved by adding antioxidants to the product.

Thus, in [13], the effect of adding vitamin E and rosemary extract to chopped semi-finished beef products was studied. Putative inhibitors in the reaction of HAA formation were added to beef cutlets with a fat content of ≈15% in the form of 1% and 10% solutions in 1 cm^3 of corn oil. Cutlets with added corn oil were used as a control sample. The results are presented in Table 1.

Table 1: Effect of vitamin E and rosemary extract on the amount of HAA formed in beef cutlets [13]

Analyte	Concentration of vitamin E and rosemary extract added into beef cutlets				
	Control sample	1% vitamin E	10% vitamin E	1% rosemary extract	10% rosemary extract
IQ					
Concentration, ng/g	5,3±3,5	0,7±0,2	0,6±0,2	1,5±0,6	1,5±1,3
Decreasing, %		85,7	88,1	72,4	71,9
MeIQ					
Concentration, ng/g	3,5±1,2	0,8±0,4	1,3±0,6	0,7±0,3	1,8±0,9
Decreasing, %		78,6	64,3	87,0	47,9
MeIQx					
Concentration, ng/g	5,7±1,7	2,9±1,9	4,1±0,8	3,8±0,7	5,1±0,3
Decreasing, %		48,0	26,0	30,1	12,1
DiMeIQx					
Concentration, ng/g	4,7±4,4	1,0±0,3	1,4±0,2	1,1±0,6	1,4±0,1
Decreasing, %		79,2	70,5	77,0	68,3
PhIP					
Concentration, ng/g	31,3±13,5	9,6±5,3	8,6±3,9	17,4±2,9	17,3±12,1
Decreasing, %		69,0	72,5	44,0	44,6

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Studies have shown that both vitamin E and rosemary extract have a strong inhibitory effect on the formation of HAA in meat products during heat treatment. Moreover, in the reaction of MeIQx and PhIP formation, most significant impact was achieved by adding vitamin E to the product.

The effect of adding rosemary extract to chopped semi-finished beef products was also studied in another work [15]. In addition to rosemary extract, they have studied the inhibitory effect of grape seed extract. Grape seed extract was added to the product by adding 1.5 g of a water-in-oil emulsion at concentrations of 0.2%, 0.4%, 0.6%, and 0.8%. Rosemary extract was added to the product by adding 1.5 g of sunflower oil with concentrations of 0.12%, 0.4%, 0.6%, 1.0%, and 1.5%. Meat products with the addition of 1.5 g of sunflower oil and 1.5 g of a water-in-oil emulsion were taken as control samples. The results obtained are shown in tables 2 and 3.

Table 2: The effect of adding grape seed extract on the amount of HAA formed in beef cutlets [15].

Analyte	Control sample	Grape seed extract added in water-in-oil emulsion at concentrations, %			
		0,2	0,4	0,6	0,8
MeIQ, ng/g	1,0±0,27	0,5±0,1	0,5±0,1	0,4±0,04	0,3±0,01
PhIP, ng/g	0,3±0,07	0,2±0,04	0,2±0,04	0,2±0,08	<0,02
Norharman, ng/g	0,5±0,02	0,5±0,01	0,5±0,03	0,7±0,03	0,6±0,01
Harman, ng/g	1,1±0,02	1,1±0,02	1,1±0,02	1,6±0,02	1,7±0,02

Table 3: The effect of adding rosemary extract on the amount of GAA formed [15].

Analyte	Control sample	Rosemary extract added in sunflower oil in concentrations, %				
		0,12	0,4	0,6	1,0	1,5
MeIQ, ng/g	0,7±0,05	0,6±0,07	0,6±0,07	0,6±0,04	0,5±0,05	0,3±0,03
PhIP, ng/g	0,2±0,02	0,2±0,02	0,1±0,04	0,1±0,03	0,06±0,01	0,02±0,01
Norharman, ng/g	0,2±0,02	0,3±0,03	0,3±0,01	0,3±0,01	0,2±0,01	0,3±0,02
Harman, ng/g	0,6±0,01	0,9±0,09	0,9±0,09	0,5±0,05	0,6±0,02	0,6±0,05

The results of the studies have shown that for such HAAs as MeIQx and PhIP, the most significant reduction was achieved when the water-in-oil emulsion with a grape seed extract concentration of 0.8% was added to the product. However, this method has led to an increase in the amount of HAA such as Harman and Norharman. The addition of rosemary extract to the product, in the same way as in [13], described earlier, led to a decrease in the amount of HAA formed, but in this case, the inhibitory effect was weaker. This may be due either to differences in the oils used to add rosemary extract to the meat product or to the heat treatment method sincein [15], the concentrations of HAA were significantly lower than in the studies conducted in [13].

In [16], the inhibitory effect of pomegranate seed extract was studied in the preparation of minced poultry and beef products. Here, in addition to the meat component and a potential inhibitor were also added to the minced meat fat to achieve 25% fatness, breadcrumbs in an amount of 20% by weight of the product, onion, salt, and spices. Then the pomegranate seed extract was added at a concentration of 0.5%. Next, the minced meat was formed into cutlets 1.5 cm thick and 5.0 cm in diameter, weighing approximately 30 g. The products were subjected to heat treatment in four ways:

1. Baking in the oven for 27 minutes at 180˚C
2. Frying in a pan at 180°C for 8 minutes on each side without using oil
3. Charcoal barbecue. For this, a kilogram of coals was used. After the combustion of charcoal the product was cooked for 10 minutes on each side. The distance between the coals and the product was 8 cm. The surface temperature of the products, in this case, was about 280˚C
4. Deep frying at 150˚C oil temperature for 5 minutes The results are shown in Table 4.

Table 4: Results of the study of the inhibitory effect of pomegranate seed extract [16].

	Heat treatment method		Analyte				
			PhiP, ng/g	Norharman, ng/g	Harman, ng/g	IQ, ng/g	MeIQx, ng/g
Beef	1	Control sample	0,57±0,06	2,65±0,14	1,29±0,12	139,21±15,39	29,55±5,05
		Experiment sample	0,48±0,12	3,43±0,14	2,10±0,39	126,71±17,55	30,21±9,07
	2	Control sample	1,11±0,18	3,14±0,55	1,38±0,03	44,65±0,77	n/d

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		Experiment sample	0,42±0,03	2,45±0,14	1,14±012	60,69±23,24	13,05±0,88
	3	Control sample	1,23±0,15	6,87±0,28	1,32±0,18	303,06±19,94	35,21±8,30
		Experiment sample	0,39±0,03	5,20±0,42	1,08±0,03	188,71±21,59	15,18±6,59
	4	Control sample	0,69±0,03	1,88±0,11	n/d	122,80±4,25	29,72±1,41
		Experiment sample	0,51±0,09	2,26±0,13	n/d	67,91±7,44	12,90±3,37
Poultry	1	Control sample	1,92±0,03	5,49±0,55	1,20±0,0	58,79±9,70	23,04±0,57
		Experiment sample	0,48±0,06	3,04±0,14	2,46±0,12	83,74±144	66,54±10,33
	2	Control sample	0,75±0,03	4,73±0,03	3,21±0,18	5,53±1,12	6,06±2,16
		Experiment sample	0,24±0,03	3,24±0,13	2,31±0,12	12,73±2,95	7,17±0,84
	3	Control sample	0,87±0,21	11,47±0,14	3,42±0,12	55,54±16,17	n/d
		Experiment sample	0,24±0,09	4,90±0,26	2,73±0,18	34,55±1,06	26,20±4,71
	4	Control sample	0,30±0,03	2,26±0,13	n/d	7,97±4,04	111,62±12,18
		Experiment sample	0,48±0,06	1,08±0,14	n/d	4,31±2,31	56,49±6,63

As can be seen from Table 4, there was an increase in the amount of HAA formed in many experimental samples relative to control samples. This is most likely due to a much larger number of factors that can affect the amount of HAA formation since the product contained many more components besides meat and a potential inhibitor.

In [17], the inhibitory effect of hawthorn extract was studied. In this work, steaks 1 cm thick were prepared from poultry and beef, which were treated by rubbing in solutions of hawthorn extract in distilled water with concentrations of 0.5% and 1.0%. Products were subjected to heat treatment by frying in a pan and baking in an oven at temperatures of 150, 200°C and 250°C. The results are shown in tables 5 and 6.

Table 5: Effect of hawthorn extract on the formation of HAA in chicken [17].

Heat treatment method	Tempterature of heat treatment, °C	Concentration of hawtorn exract, %	Analyte			
			IQ, ng/g	IQxng/g	MeIQng/g	MeIQxng/g
Pan frying	150	0	n/d	0,14	0,82	0,05
		0,5	0,18	0,12	0,15	0,43
		1,0	n/d	0,18	n/d	0,60
	200	0	0,17	0,17	n/d	0,45
		0,5	0,17	0,17	n/d	0,49
		1,0	n/d	n/d	n/d	0,38
	250	0	1,52	0,14	n/d	0,79
		0,5	n/d	n/d	0,46	0,41
		1,0	n/d	n/d	0,43	0,52
Baking	150	0	n/d	0,38	n/d	n/d
		0,5	n/d	n/d	n/d	n/d
		1,0	n/d	0,03	n/d	n/d
	200	0	n/d	0,15	n/d	0,14
		0,5	n/d	0,20	n/d	n/d
		1,0	n/d	0,14	n/d	n/d
	250	0	0,38	0,69	0,19	0,60
		0,5	n/d	0,64	0,29	0,60
		1,0	4,47	n/d	n/d	0,58

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Table 6: Effect of hawthorn extract on the formation of HAA in beef [17].

Heat treatment method	Tempterature of heat treatment, ˚C	Concentration of hawtorn exract, %	Аналит			
			IQ, ng/g	IQx, ng/g	MeIQ, ng/g	MeIQx, ng/g
Pan frying	150	0	n/d	0,14	0,82	0,05
		0,5	0,18	0,12	0,15	0,43
		1,0	n/d	0,18	n/d	0,60
	200	0	n/d	0,17	n/d	0,45
		0,5	n/d	0,17	n/d	0,49
		1,0	n/d	n/d	n/d	0,38
	250	0	1,52	0,14	n/d	0,79
		0,5	n/d	n/d	0,46	0,41
		1,0	n/d	n/d	0,43	0,52
Baking	150	0	n/d	0,38	n/d	n/d
		0,5	n/d	n/d	n/d	n/d
		1,0	n/d	0,03	n/d	n/d
	200	0	n/d	0,15	n/d	0,14
		0,5	n/d	0,20	n/d	n/d
		1,0	n/d	0,14	n/d	n/d
	250	0	0,38	0,69	0,19	0,60
		0,5	n/d	0,64	0,29	0,60
		1,0	4,47	n/d	n/d	0,58

The results obtained are highly contradictory since were observed an increase and a decrease in the amount of HAA in the experimental samples relative to the control ones. Such results can be explained either by the method of adding the extract, which does not allow uniform distribution of the potential inhibitor in the product, in contrast to the cases when it is added to minced meat or by the absence of pronounced inhibitory properties in the hawthorn extract.

Similarly, the inhibitory properties of the artichoke extract were studied in [18]. As in [17], steaks 1 cm thick were prepared from poultry and beef meat, which were treated by rubbing artichoke extract solutions in distilled water with concentrations of 0.5% and 1.0%. Products were subjected to heat treatment by frying in a pan and baking in an oven at temperatures of 150˚C, 200˚ C and 250˚ C. The results are shown in tables 7 and 8.

Table 7: Effect of artichoke extract on the formation of HAA in chicken [18].

Heat treatment method	Tempterature of heat treatment, ˚C	Concentration of artichoke exract, %	PhIP, ng/g	IQxng/g	MeIQng/g	MeIQxng/g
Pan frying	150	0	n/d	0,07±0,02	0,85±0,12	0,29±0,04
		0,5	n/d	0,15±0,01	1,71±0,33	0,60±0,12
		1,0	n/d	0,16±0,02	1,58±0,13	0,60±0,20
	200	0	n/d	0,18±0,01	4,79±0,97	1,30±0,45
		0,5	n/d	0,49±0,02	3,36±0,42	1,16±0,08
		1,0	n/d	0,56±0,05	5,20±1,29	1,91±0,39
	250	0	4,86±0,27	1,57±0,04	3,69±0,17	1,40±0,30
		0,5	5,14±0,46	1,19±0,39	3,55±1,13	1,50±0,30
		1,0	7,00±1,10	1,14±0,16	2,77±0,29	1,21±0,15
Baking	150	0	0,35±0,07	0,08±0,01	n/d	n/d
		0,5	n/d	n/d	n/d	n/d
		1,0	n/d	n/d	n/d	n/d
	200	0	n/d	0,09±0,04	0,33±0,06	0,10±0,00
		0,5	n/d	n/d	0,22±0,02	0,08±0,02
		1,0	n/d	n/d	0,37±0,03	0,14±0,03
	250	0	n/d	0,75±0,07	12,05±1,38	1,66±0,37
		0,5	n/d	0,23±0,03	3,24±0,61	0,95±0,10
		1,0	n/d	0,26±0,03	3,99±0,36	0,95±0,11

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Table 8: Effect of artichoke extract on the formation of HAA in beef [18].

Heat treatment method	Tempterature of heat treatment, ˚C	Concentration of artichoke exract, %	PhIP, ng/g	IQxng/g	MeIQng/g	MeIQxng/g
Pan frying	150	0	n/d	3,48±0,47	2,02±0,24	0,68±0,08
		0,5	n/d	2,47±0,24	3,20±0,20	1,19±0,18
		1,0	n/d	1,59±0,42	2,38±0,40	0,88±0,06
	200	0	n/d	2,13±0,13	4,39±0,48	1,44±0,33
		0,5	n/d	0,71±0,05	4,71±0,68	1,71±0,33
		1,0	n/d	0,45±0,07	4,98±0,23	1,80±0,60
	250	0	3,19±0,18	1,54±0,07	6,17±0,39	1,76±0,01
		0,5	3,57±0,07	1,31±0,01	5,51±0,13	1,90±0,20
		1,0	7,59±0,59	1,95±0,02	6,35±0,04	2,20±0,10
Baking	150	0	4,52±0,26	3,13±0,10	0,14±0,04	n/d
		0,5	2,34±0,03	1,92±0,11	0,08±0,01	n/d
		1,0	1,48±0,04	1,74±0,05	0,05±0,00	n/d
	200	0	0,50±0,0	0,37±0,10	0,19±0,02	0,06±0,3
		0,5	n/d	1,59±0,07	n/d	n/d
		1,0	n/d	1,08±0,01	0,19±0,04	0,05±0,03
	250	0	0,53±0,05	2,73±0,03	7,25±0,70	1,25±0,02
		0,5	n/d	0,91±0,01	5,93±0,05	1,29±0,45
		1,0	n/d	0,87±0,02	0,05±0,03	0,03±0,02

In contrast to hawthorn extract, treatment with artichoke extract solution resulted in a decrease in the amount of HAA formed in the meat product, except for PhIP in chicken and beef samples prepared by frying in a pan at a temperature of 250°C, where a catalytic effect was observed.

In [19], the effect of replacing animal fat with vegetable oils was studied. The essence of the experiment was that cutlets were made from defatted pork with the addition of pork fat, sunflower, olive, and pomegranate oils. Sample formulations are shown in Table 9.

Table 9: Recipe of research objects.

	Ingreadients, g/kg				
	Defatted meat	Oil	Pork fat	Salt	Water
Control	700	0	100	20	180
Sample with sunflower oil	700	40	60	20	180
Sample with olive oil	700	40	60	20	180
Sample with promegranate oil	700	40	60	20	180

From the prepared minced meat, cutlets were formed, weighing about 100 g, 9.0 cm in diameter, and 2.5 cm thick. These cutlets were baked in an oven at temperatures of 180°C and 220°C until the temperature inside the product reached 73°C. The obtained results are shown in Table 10.

Table 10: Results of the effect of replacing animal fat with vegetable oils on the amount of HAA formed.

Sample	Температура обработки	IQ, ng/g	MeIQ,ng/g	MeIQx,ng/g	DiMeIQx,ng/g	PhIP,ng/g
Control	180	n/d	18,26±14,46	8,34±1,78	25,66±1,51	11,43±6,33
	220	3,88±3,50	59,70±0,98	13,45±7,43	43,37±15,67	24,07±1,99
With olive oil	180	0,58±0,01	n/d	3,50±0,68	n/d	n/d
	220	1,30±0,42	n/d	2,52±0,36	1,31±0,22	14,78±1,49
With sunflover oil	180	n/d	n/d	4,32±0,50	1,02±0,50	n/d
	220	0,64±0,16	n/d	4,31±0,55	5,12±0,35	22,70±1,95
With promegranate oil	180	n/d	n/d	n/d	n/d	n/d
	220	0,59±0,04	1,31±0,06	n/d	n/d	n/d

The results have shown that replacing of 40% of animal fat in a meat product with vegetable oil leads to a significant reduction in the amount of HAA formed during heat treatment. The decrease in the total amount of HAA in products ranged from 83% to 100%. This effect can be explained by the high content of vitamin E

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in vegetable oils As already described earlier, vitamin E has a strong inhibitory effect in the formation of HAA.

III. Conclusion

The analyzed works have shown that the risk of HAA formation can be controlled in various ways, the most accessible of which is to introduce ingredients with antioxidant activity into the meat product recipe. By such methods, it is possible to reduce the level of HAA up to 100%, which will reduce the carcinogenic load on the human body with endogenous xenobiotics and improve food safety. The analysis of the results of the studied works made it possible to determine the vector for further own research on this issue, namely, the introduction into the recipe of meat products ingredients that usually used to be added and ingredients that were not used, but have high antioxidant activity, such as sea buckthorn, blueberries, grapes, cranberries, mountain ash, chokeberry, currant, mangosteen.

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Global Environmental Pollution and Its Effect on Life Expectancy

By Dr. M. A. Quader

Abstract- Current status of global life expectancy increase is explained. Environmental pollution is a threat to human civilization, a threat to life expectancy. The loss of life years and life expectancy in the global context are identified and quantified. The potential gains in life expectancy are also identified and quantified.

Keywords: life expectancy, pollution, effect of pollution.

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Global Environmental Pollution and Its Effect on Life Expectancy

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Abstract- **Current status of global life expectancy increase is explained. Environmental pollution is a threat to human civilization, a threat to life expectancy. The loss of life years and life expectancy in the global context are identified and quantified. The potential gains in life expectancy are also identified and quantified.**

Keywords: life expectancy, pollution, effect of pollution.

Terms

LE Life Expectancy (years)
LEB Life expectancy at birth(years)
LLE Loss of life expectancy (years)
YLL Years of life lost
CD Communicable disease
NCD Non communicable disease
DALY Disability Adjusted Life Years

I. Environmental Pollution

Environment problem is a very big issue and problem for the human society. More than 7 million people die each year from air pollution, according to a new study. It is far more than the estimated 2.6 million people who have died from Covid-19 since it was detected more than a year ago.

Pollution is the world's largest environmental threat to health, responsible in 2020 for an estimated 10 million premature deaths, or 15% of all deaths globally, and 275 million Disability-Adjusted Life Years. This is equal to 0.035 year life expectancy lost on global basis.

Annual deaths due to environmental pollution world over are shown in the following table (Table 1.1). More than three fourths deaths occur due to air pollution. One fifth of the deaths occur due to water pollution. About 4% deaths occur due to land pollution. For better visualization, this is also shown in figure (Fig 1.1).

Table 1.1: Global Deaths due to Pollution([01])

Item	Global Deaths (million)	Percent
Air Pollution	7.00	76.17
Water Pollution	1.80	19.59
Land Pollution	0.39	4.24
Total	9.19	100.00

As can be seen from the table, 76.17% of the deaths occur due to air pollution followed by water pollution. Long-term health effects from air pollution include heart disease, lung cancer, and respiratory diseases such as emphysema. Air pollution can also cause long-term damage to people's nerves, brain, kidneys, liver, and other organs. Some scientists suspect air pollutants cause birth defects.

Water pollution causes typhoid, cholera, hepatitis and various other diseases and destruction of Ecosystems: Ecosystems are extremely dynamic and respond to even small changes in the environment. Water pollution can cause an entire ecosystem to collapse if left unchecked.

Author: e-mail: qudratq@gmail.com

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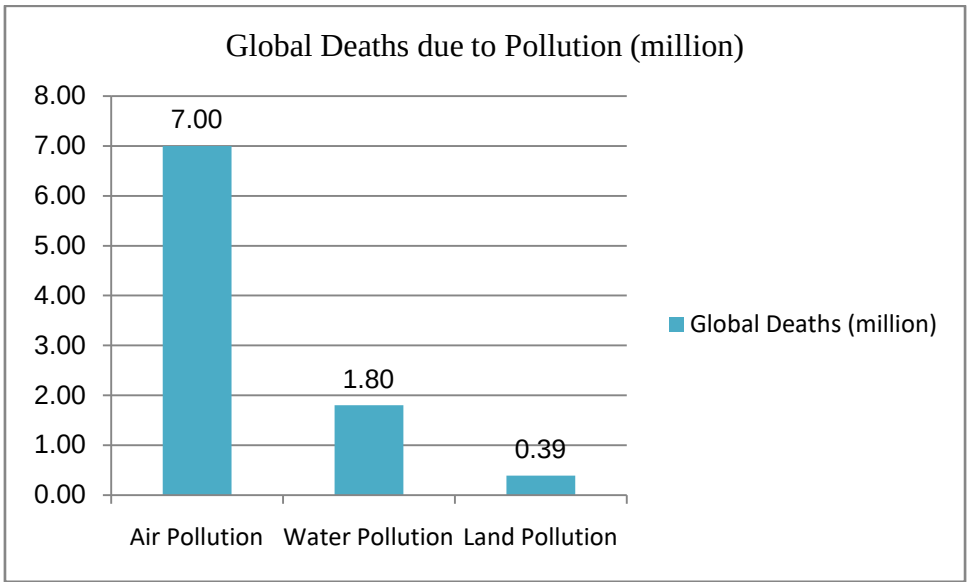

Fig. 1.1: Global Deaths due to Pollution

Within the pollution sector, air pollution is the most damaging one. Worldwide it causes 76.17% of all the pollution deaths. The Premature deaths attributable to the components of air pollution are shown in Table 2. See also Fig. 1.2.

Table 1.2: World Air Pollutants Yearly Premature Deaths

Sl No.	Air Pollutant	World Yearly Deaths
1	Particulate Matter	4,200,000
2	Carbon Monoxide	1,062,161
3	Lead	853,000
4	Nitrogen Oxides	10,000
5	Ozone	6,000
6	Sulfur Dioxide. Notsignificant	
7	Other Air Pollutants. Not significant	
	Total	6,131,161

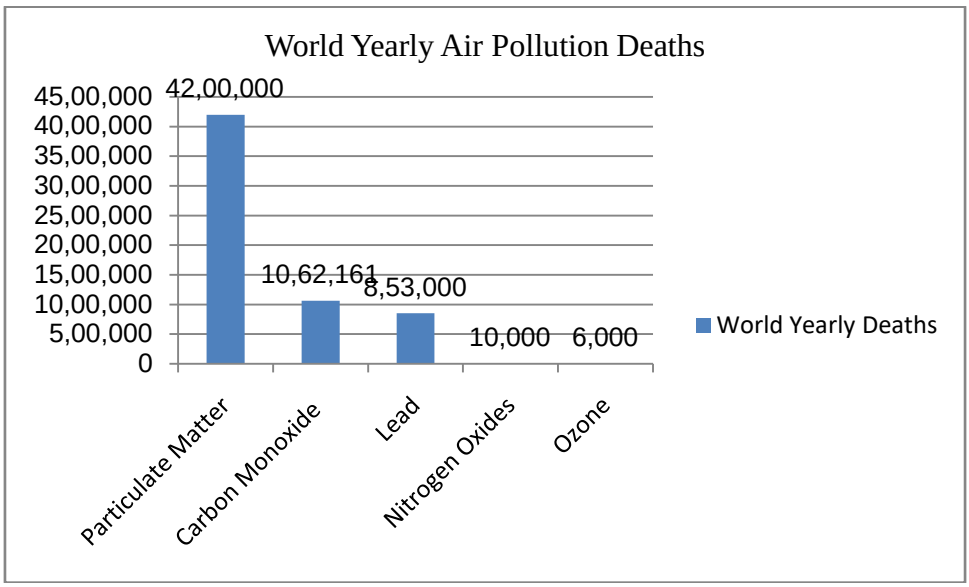

Fig. 1.2: World Yearly Air Pollution Deaths

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Trend of air pollution in the world is shown in figure 1.3. It is good to see that world deaths are consistently decreasing. The decreasing rate is 1.87 per 100,000 people per year.

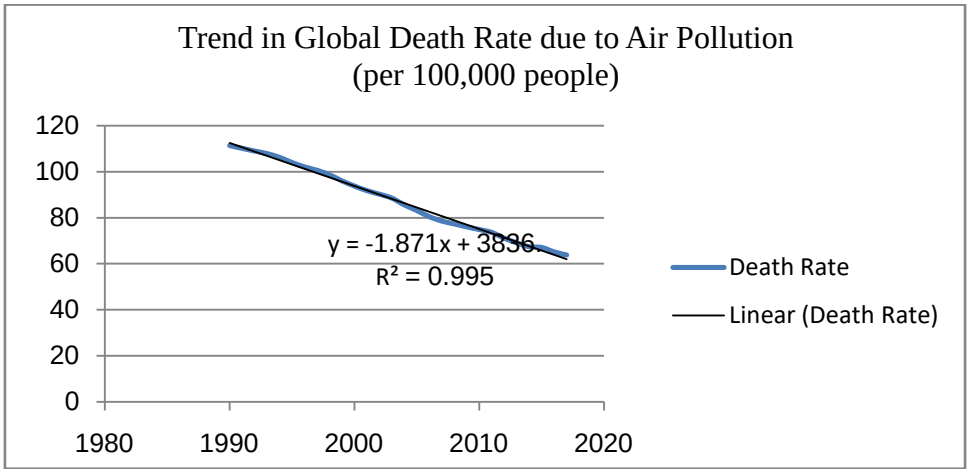

Fig. 1.3: Global Death Rate due to Air Pollution

According to World Health Organization, Air Pollution causes 7 million premature deaths a year([02]). The World Health Organization (WHO) said air pollution was now one of the biggest environmental threats to human life, leading to seven million premature deaths a year.

a) Life Expectancy

Life expectancy is a statistical measure of the average time the human are expected to live, based on the year of its birth, its current age, and other demographic factors including sex. The most commonly used measure is life expectancy at birth (LEB).

The factors that help increase human life expectancy are better health care and hygiene, healthier life styles, sufficient food and improved medical care and reduced child mortality mean that people can expect to live much longer than our ancestors just a few generations ago.

Despite some odds, especially in the pollution sector, world death rate is declining. As a result, world life expectancy is increasing. This is depicted in Table 2.1 and Figure 2.1.

Table 2.1: World Crude Death Rate

	Crude Rateper 1000 people						
Year	1960	1970	1980	1990	2000	2010	2020
Rate	17.712	11.994	10.272	9.226	8.592	7.888	6.09

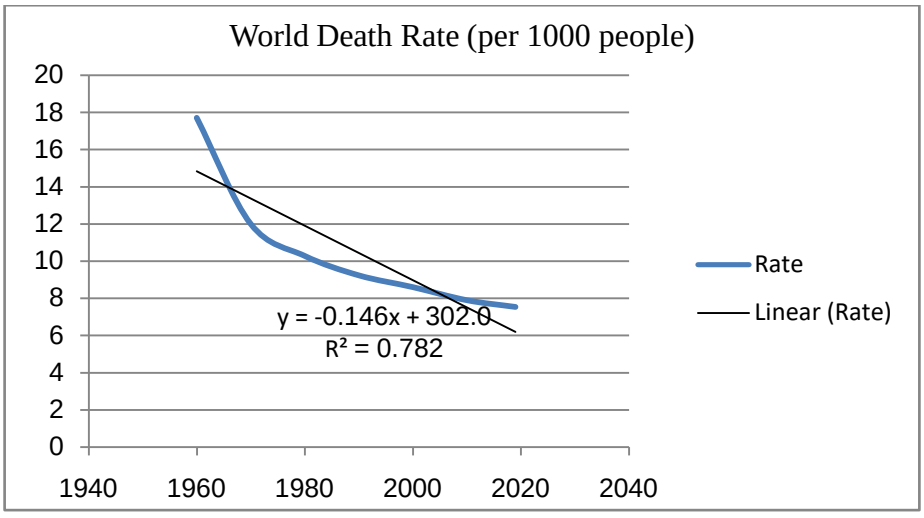

Fig. 2.1: Trend in World Death Rate

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Another odd is increase in the life year losses due to non - communicable diseases (NCD). This is evident from figure 2.2.

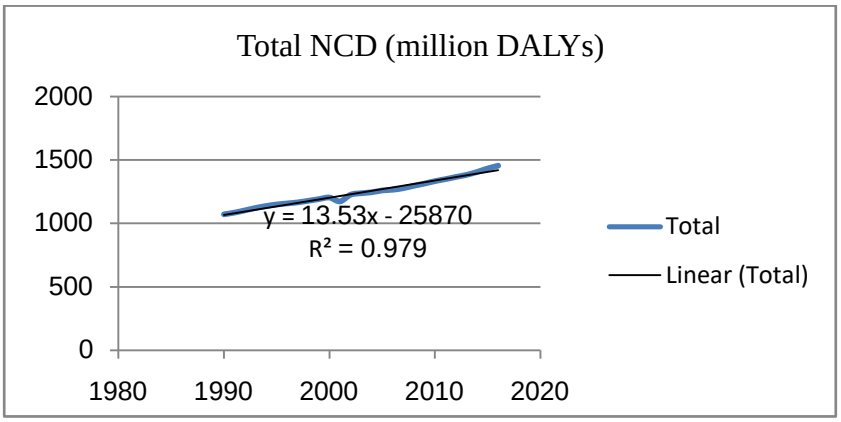

Fig. 2.2: Trend in the NCD

The average Life expectancy data of world population for several years is plotted and presented in Fig 2.3. The trend line is also shown. The statistical model with parameters is shown.
Statistical model is

Life Expectancy (years) = 0.3205 * years – 573.23

R^2 = 0.9671; time period 960 – 2016.

However the average life expectancy is consistently increasing. Every year, 0.3205 year is increasing in the world population life expectancy on average. This means every three years, one year life expectancy is increasing on the average life expectancy of the world population meaning 4 months in every year. See Fig. 2.3

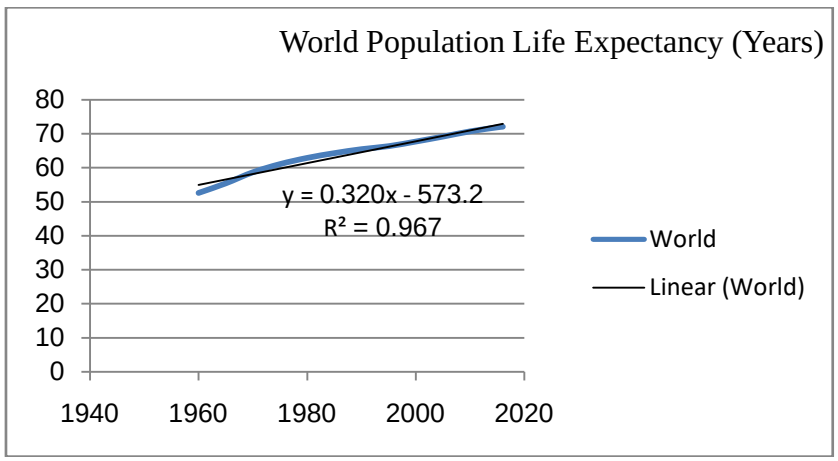

Fig. 2.3: Trend of Life Expectancy of World Population

Since the world countries are much heterogeneous in characters, there are also variations in the life expectancies between different countries, regions and level of economic development. In the table and figure here the variations in life expectancy based on the World Bank Income Groups are depicted. See the Table 2.4 and Fig. 2.4.

Table 2.4: Life Expectancy by World Bank Income Group

Sl no.	WB Income Group	Life Expectancy (years) 2020
1	High Income	81.84
2	World	74.18
3	Middle income	74.28
4	Low & Middle income	73.13
05	Lower Middle income	70.21
6	Low Income	63.43

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High income group has the highest life expectancy (81.84 years). Placed in order, the low income group has the lowest life expectancy (63.43 years). The trend of the life expectancies of the WB income groups is shown in figure 2.4.

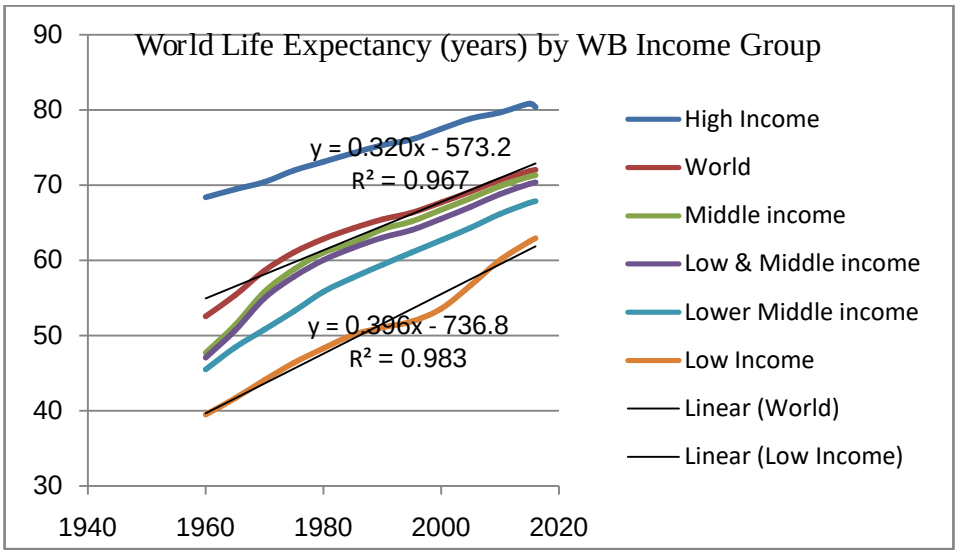

Fig. 2.4: World Life Expectancy (years) by WB Income Groups

Relationship between Life Expectancy and Income Groups is shown in this figure. The trend line of low income group runs at the bottom of all lines indicating lowest level of life expectancy.

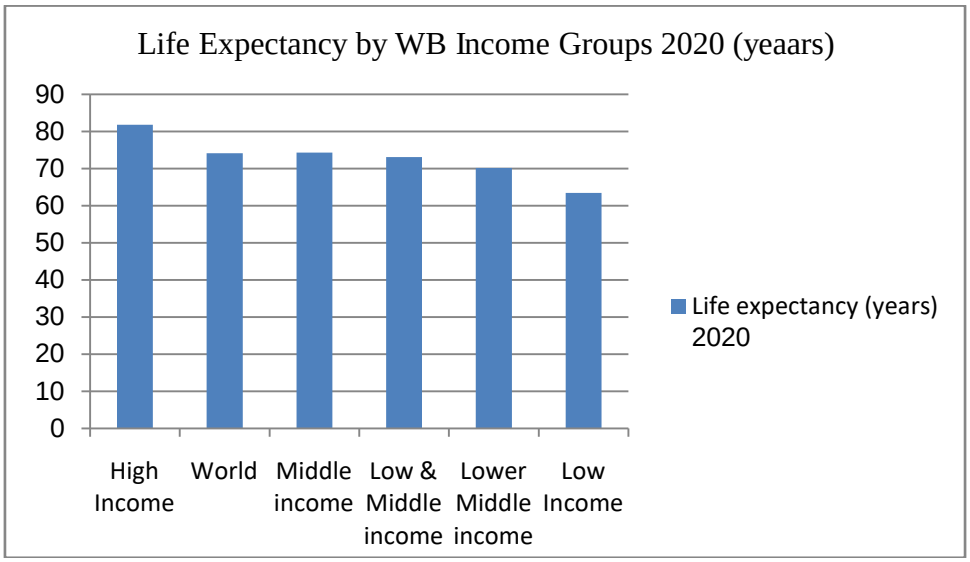

Fig. 2.5: Life Expectancy by WB Income Group 2020 (years)

II. Effect of Environmental Pollution on Life Expectancy

a) Life Expectancy Loss

Life year loss to the world is the most important effect pollution inflicts on the world people. In this connection, Disability Adjusted Life Years Lost in the world in 2020 in NCD is shown in the following table (Table 3.1).

Here it can be seen that the maximum loss (19.22%) occurs due to cardiovascular disease followed by cancer (12.27%). These two diseases burden together account for 31.49% of all the diseases.

The life year losses on account of these diseases are shown in Table 3.1.

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Table 3.1: DALY – Disability Adjusted Life Years Lost and Life Expectancy Lost in 2020 (Burden of Diseases – NCD, 2020)

SI No.	Disease	DALY lost (million)	Percent	Life Expectancy Lost (Year)
1	Cardiovascular Disease	365.87	19.22	0.04720
2	Cancer	233.51	12.27	0.03012
3	Neonatal Disorders	185.78	9.76	0.02397
4	Musculoskeletal disorders	138.72	7.29	0.01789
5	Mental and substance use disorders	122.76	6.45	0.01584
6	Other NCDs	121.89	6.40	0.01572
7	Respiratory diseases	112.32	5.90	0.01449
8	Neurological disorders	111.17	5.84	0.01434
9	Unintentional injuries	105.94	5.57	0.01367
10	Digestive diseases	85.29	4.48	0.01100
11	Transport injuries	75.33	3.96	0.00972
12	Malaria & neglected tropical diseases	62.28	3.27	0.00803
13	Nutrition Deficiencies	58.03	3.05	0.00749
14	Liver Disease	41.40	2.18	0.00534
15	Self Harm	34.01	1.79	0.00439
16	Interpersonal Violence	26.00	1.37	0.00335
17	Maternal Disorders	11.80	0.62	0.00152
18	Conflict and Terrorism	10.10	0.53	0.00130
19	Natural Disaster	1.20	0.06	0.00015
	Total	1903.4	100.00	0.24554

The total DALY (disability adjusted life year lost) is equivalent to 0.25 year life expectancy loss on world average.

For the Communicable diseases, see the following table (Table 3.2) and the figure(Fig 5).

Table 3.2: DALYs Lost (million) in Communicable Diseases (CD)

Year	DALY Lost (million) 2020	Percent	Life Expectancy Lost (Years)
Maternal Disorders	11.26	1.92	0.00145
Other Communicable	22.67	3.87	0.00292
Tuberculosis	42.26	7.21	0.00545
HIV/AIDs	41.04	7.01	0.00529
Nutritional Deficiencies	52.84	9.02	0.00682
Malaria & Tropical	60.26	10.29	0.00777
Neonatal Disorders	185.78	31.72	0.02397
Diarrhea etc	169.66	28.96	0.02189
Total CD	585.77	100.00	0.07556
Injuries (including violence, conflict, and self-harm)			0.00042

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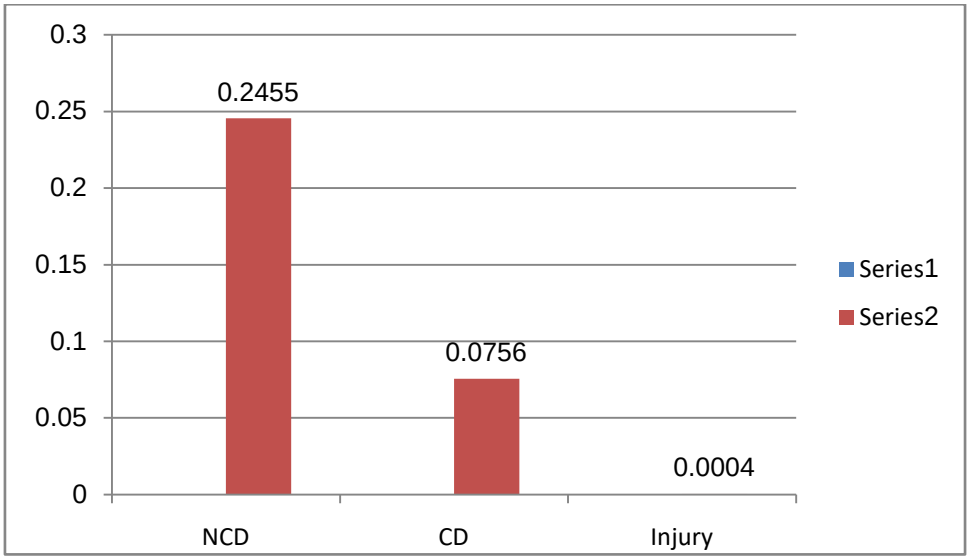

Fig. 3.1: Life Expectancy Lost (Year) by Burden of Diseases

The total loss per year on account of CD is equivalent to 0.076 year life expectancy loss on the whole world. The life year loss due to CD is 30.77% of that of NCD.

b) Shortening of Life Expectancy

Environmental pollution has adverse effect on human life. It shortens the life expectancy. World picture of shortening of life expectancy by pollution is shown in Table 3.2.

Table 3.2: Life Expectancy Shortened in the World by Pollution (2020)

Sl no.	Factor	Life Expectancy Shortened (Years)	No People in World (million)	Life Years Each Factor (million)
1	Air Pollution	1.90	5200	9,880.00
2	Smoking	1.80	1,100	1,980.00
3	Alcohol, Drug Use	0.92	2,000	1,833.33
4	Unsafe Water	0.50	144	72.00
5	Road Injuries	0.42	55	22.92
6	HIV/AIDS	0.33	38	12.63
7	Malaria	0.50	229	114.50
8	Diabetes	6.50	463	3,009.50
9	Heavy Stress	2.80	2,714	7,599.20

Life expectancy is shortened maximum by air pollution (1.90 years) resulting a loss of life years of 9,880.00 million life years followed by heavy stress 7,599.20 life years. Overall, the picture of world life year losses (2020) is shown in figure 3.1.

The life expectancy shortening and losses of life years are shown graphically in figures 3.2 and 3.2,

Fig. 3.2: Life Expectancy (years) Shortened

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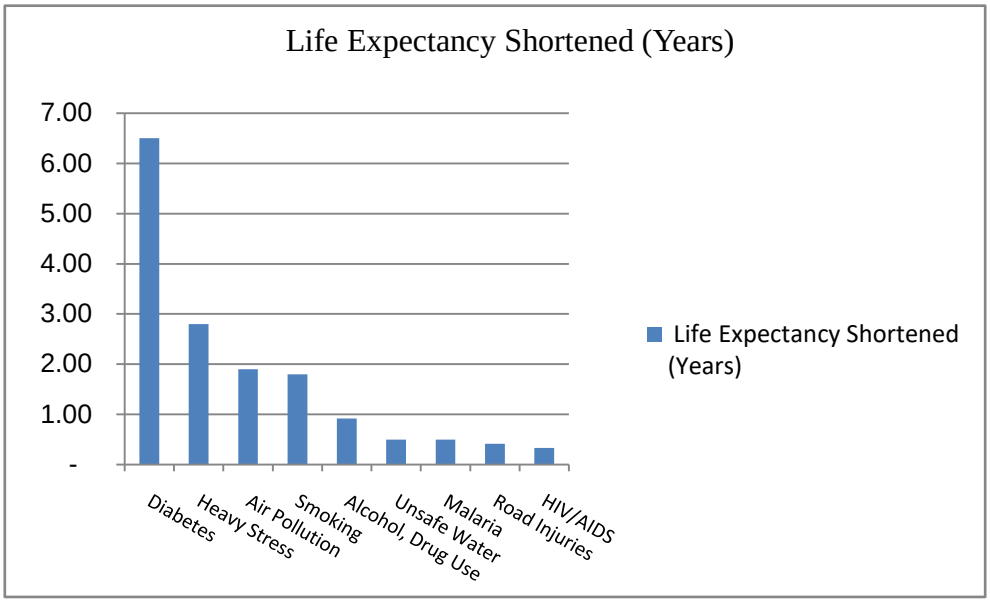

Fig. 3.2: Life Years Shortened by Each Factor (million)

In this connection it may be noted that in total, 20,507,518 years of life have been lost to COVID-19 among the studied 81 countries, due to 1,279,866 deaths from the disease. The average years of life lost per death is 16 years. Feb 18, 2564 BE. This is equivalent to shortening of 0.0026 year of life expectancy loss of the entire world on average.

c) *Potential Gains in Life Expectancy*

It is noted that if the measures can be taken to stop the losses in full, the losses can be recovered in full and the life expectancy can be increased to the extent shown. But it is really difficult to achieve this. So, two scenarios are prepared for potential gains in the average expected life years.

Scenario A: Elimination of all deaths from specific diseases in people aged 30–70 years

Scenario B: Reduction in deaths from specific disease in people aged 30–70 years by a third.

Both the scenarios are shown in Table 3.3. The Sustainable Development Goal is set by the United Nations.

(The Lancet GlobalHealth) estimated in the Sustainable Development Goal two scenarios of potential gains.

The potential gains in life expectancy from the diseases according to World Bank Income Group are shown in Table 3.3.

Table 3.3: Potential Gain in Average Expected Years Lived between Ages 30 and 70 Yearsin 2015 by Cause of Death

Factors	Scenario A (years)	Scenario B (years)
All NCDs	2·22	0.80
Major NCDs	1·78	0·64
(1) Cardiovascular diseases	0·87	0·32
(2) Cancer	0·69	0·26
(3) Chronic respiratory diseases	0·17	0·09
(4) Diabetes	0·14	0·08
All other NCDs	0·44	0·18
Injuries	0·52	0·20
All other causes	0·62	0·24
All CDs	0.15	0.06

Scenario A: Elimination of all deaths from specific diseases in people aged 30–70 years
Scenario B: Reduction in deaths from specific disease in people aged 30–70 years by a third (Sustainable Development Goal).
Source: The Lancet Global Health

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The potential gains in average expected life years and other related information are shown in Table 3.4([04]).

Table 3.4: Potential Gain in Average Expected Life Years Lived between Ages 30 and 70 Years in 2015 by cause of Death and World Bank Economic Groups

Cause of Death	Low-income countries		Lower-middle-income countries		Upper-middle-income countries		High-income countries	
	Scenario A	Scenario B	Scenario A	Scenario B	Scenario A	Scenario B	Scenario A	Scenario B
All NCDs	2·75	1·01	2·82	1·03	1·98	0·72	1·46	0·52
Major NCDs	2·18	0·80	2·20	0·81	1·66	0·61	1·11	0·40
(1)Cardiovascular diseases	1·01	0·39	1·20	0·45	0·78	0·30	0·40	0·15
(2) Cancer	0·85	0·33	0·65	0·26	0·72	0·27	0·61	0·22
(3) Chronic respiratory diseases	0·23	0·12	0·26	0·13	0·14	0·08	0·09	0·05
(4) Diabetes	0·17	0·10	0·19	0·10	0·12	0·07	0·07	0·04
All other NCDs	0·58	0·24	0·59	0·24	0·34	0·14	0·36	0·14
Injuries	0·76	0·30	0·59	0·24	0·50	0·20	0·31	0·12
All other causes	2·22	0·80	0·94	0·36	0·32	0·14	0·10	0·05

Scenario A: Elimination of all deaths from specific diseases in people aged 30–70 years
Scenario B: Reduction in deaths from specific disease in people aged 30–70 years by a third (Sustainable Development Goal)
Source: The Lancet Global Health

Differences can better be visualized from the figure 3.4. Maximum and almost the same value of life expectancy are achieved in low income countries and lower middle income countries.

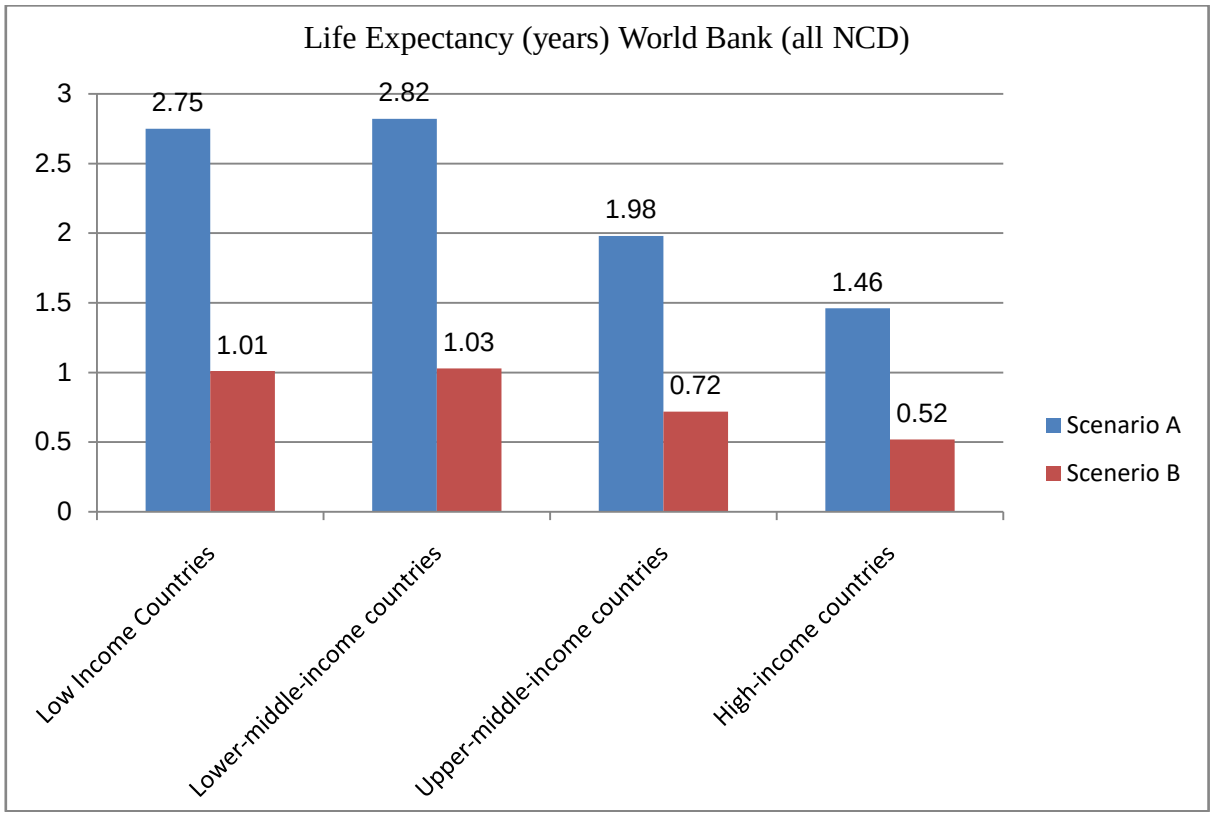

Figure 3.4: Potential Gains in Life Expectancy (years) according to World Bank (all NCD)

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Regional Life Year Loss and Life Expectancy Loss are shown in Table 3.5([02]). The variations in life year loss and life expectancy loss may be marked region wise. The avoidable life expectancy loss is in East Asia 3.0 years.

Table 3.5: Regional Life Year Loss and Life Expectancy Loss

Sl no.	Region	Mortality ($\times 10^3$/year)	Deaths per 100 000/year	YLL ($\times 10^6$/year)	LLE (years)	Avoidable LLE (years)
1	Africa	957	81	40.0	3.1	0.7
2	East Asia	3112	196	67.4	3.9	3.0
3	South Asia	2809	119	83.6	3.3	1.9
4	West Asia	544	94	14.6	2.3	1.0
5	Europe	790	133	14.3	2.2	1.7
6	Australia	14	47	0.3	0.8	0.2
7	North America	360	74	7.5	1.4	1.1
8	South America	207	42	5.3	1.0	0.5
9	World	8793	120	233	2.9	1.7

YLL Years of life lost
LLE loss of life expectancy

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Assessing the Operational Impacts of Road Intersection using PTV Vissim Microscopic Simulation

By Kutlimuratov Kudrat & Mukhitdinov Akmal

Tashkent State Transport University

Abstract- The purpose of this study is to analysis the signalized intersection performance based on traffic volume and redesigning type of intersection. The observed data were collected at signalized roundabout intersection in Tashkent, Uzbekistan for 12 hours duration on weekdays. Traffic volume were analyzed and estimated at peak hours and estimated by level of service (LOS). Traffic volumes were projected for next 5, 10 years. The results of intersection performance were LOS C based on delay values in 2020. The next five years projected volume will be exceeding than maximum capacity from existing condition data. The study was proposed to reduce the congestion level and delays using PTV vissim software. This study is expected to help traffic engineers, planners and policy makers understand the assessment of the signalized intersections under mixed traffic conditions.

GJSFR-H Classification: DDC Code: 363.125 LCC Code: HE5614



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Assessing the Operational Impacts of Road Intersection using PTV Vissim Microscopic Simulation

Kutlimuratov Kudrat [α] & Mukhitdinov Akmal [σ]

Abstract- The purpose of this study is to analysis the signalized intersection performance based on traffic volume and redesigning type of intersection. The observed data were collected at signalized roundabout intersection in Tashkent, Uzbekistan for 12 hours duration on weekdays. Traffic volume were analyzed and estimated at peak hours and estimated by level of service (LOS). Traffic volumes were projected for next 5, 10 years. The results of intersection performance were LOS C based on delay values in 2020. The next five years projected volume will be exceeding than maximum capacity from existing condition data. The study was proposed to reduce the congestion level and delays using PTV vissim software. This study is expected to help traffic engineers, planners and policy makers understand the assessment of the signalized intersections under mixed traffic conditions.

I. Introduction

In fact, the fastest growing source of global emissions is considered the transport sector in world. They are also expected to grow at faster rate than not only due to dependence on vehicles, but also due to grows urban mobility and goods transportation services. Global emissions are related to traffic congestions and have serious negative effects on an environment and human health. Traffic congestion causes the increasing of travel time, emission, air pollution, delay, long queue of vehicles, higher vehicle operating cost and so on. A city with traffic congestion has a lot of problems. Public transportation system plays a major role for the achievement of a sustainable and development of a city in the near future. Improving the operational performance of road intersection is considered one of the solutions regarding the decrease in traffic congestion and negative impacts of emissions. The transportation system has a large effect on social, environmental and economic aspects of the city.

Tashkent is a fast-growing city which is population over than 2.5 mln. It is the largest city in Central Asia. Motorization rate is approximately four times faster than population growth rate. Population growth rate is 1.5%. Motorization rate is potential to cause traffic congestion and significantly increase vehicle queues at road intersections. The past decade number of vehicles has significantly increased twice. So, traffic congestion is an effect of a growing city, a city which grows has a higher urban mobility, and sometimes at the during peak hours road capacity do not balance up to the actual demand causing congestion. Cost of loses of Tashkent city was an average of $ 138.2 million per year in 2011[1]. One of the major challenges in the city is proper traffic management and efficient organization.

In recent years, traffic signals, geometric shape and design of the road intersection has been changed several times in Tashkent for reducing traffic congestion. For instance, the intersection is shown in Figure 1 that it was changed from conventional (x-type) intersection to roundabout (o-type), from roundabout to conventional intersection. Such kind of infrastructure changes will require additional construction costs, as well as influence to safety, environmental issues and operational performance of the intersections.

Therefore, purpose of this study is to analyze the performance of intersection and in an aim regard specific improvement of the road intersection by using PTV traffic suite simulation models and to determine the occurred traffic congestion in case study of Mirabad-Shahrisabz-Mirabad-Shota Rustaveliat Tashkent as well as providing technical recommendations for improving a level of service and reducing traffic congestion. Objectives are focused on the importance of the intersection design, signal controls and operational performances and compared to the existing conditions.

Often, insufficient research has been conducted on how the efficiency of a roundabout or a conventional intersection on urban streets can affect the road network. For this reason, a systematic assessment is required to justify the most optimal alternatives when implementing long-term projects for a particular location.

In recent years, roundabouts equipped with traffic lights have been widely used, but in developing countries, as well as in Uzbekistan, there is no clear design or standard for the construction of roundabouts. We can calculate an efficient intersection design using PTV vissim software and based on develop practical recommendations. We will be able to assess and select alternative options for effective traffic management.

Author α: P.hd student, Tashkent state transport university, Tashkent, Uzbekistan. e-mail: qudratq@gmail.com
Author σ: Professor, Tashkent state transport university, Tashkent, Uzbekistan.

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a) Satellite view of intersection in 2010 b) Satellite view of intersection in 2020

Figure 1: View of the studied intersection from the Google map (41°17'44.8"N 69°16'07.2"E)

II. Literature Review

Despite of extensive research works on traffic congestion [2–10]during the past decades have focused on reducing traffic congestion and traffic safety[11–16] at signalized and unsignalized intersections, and analyzing traffic emissions. These questions are directly related to the design of intersection and characteristics.

Several studies [3,17–21]have been discussed traffic emission modeling at intersections. Computer model was developed for estimation traffic emissions for two kinds of intersections. This study presents a detailed analysis and modelling traffic flow emissions using PTV vissim software and methodology with reasonable solutions to plan a road intersection. From the analysis of the studied sources, very few researches have focused on the study of conventional and roundabout intersections.

Some studies[17–22] have studied the effects of factors such as bus travel time and travel time variability and vehicle fuel consumption at the intersection, bus delay and focused on finding solutions to minimize delays. The impact of scheduled and unscheduled stops related to bus delays was studied using a linear multivariate regression model based on the collected automatic vehicle location data.

There are many factors influencing to emission. The exhausted emissions are a product of this combustion process by burning fuels. Other significant input considered by the road emissions is street geometry, meteorological conditions, operation conditions, energy efficient vehicles and characterize the mechanical activities in the transport process, they are also related to emissions [19], [25], [27]–[29]. The studies showed that potential affects to minimize traffic negative impacts, reduce fuel consumption and emission using transport technology measures, shifting new type of fuels in power train system, technological improvements and optimal engine operation conditions, pollutant emissions per unit of length traveled have been significantly studied. Emissions are estimated by traffic data with vehicle traveled distance, speed and traffic flow data.

However, they conclude that operation conditions are a special case, where collected data can be used to general total traffic volume, but it is not necessarily true for other areas. The collected data is used to obtain traffic volume as input to the emission calculation, but only for specific vehicles and road intersections.

III. Research Method

This study used a quantitative method to assess the signalized intersection of Mirabad-Shahrisabz-Mirabad-Shota Rustaveli streets crossing in Tashkent, by considering delay, traffic queue, fuel consumption, and as well as level of service (LOS). Map showing the location of the studied intersection is shown in Figure 2. The location of study was selected for research purposewhich is described as one of the congested intersection and potential to traffic congestion, Tashkent city and the intersection was four arm signalized intersection with fixed signal time.Inthis study data collection conducted in normal working day on November 12, 2020 and included data that traffic volume, cycle times and signalized phases, vehicle queue length and average vehicle speed. Data collection was carried out on Thursday for 12 hours including the peak of the morning, afternoon, and evening.

Secondary data were for input values in PTV vissim 20 software and to calibrate the model based on the actual road conditions in Tashkent.

Based on the analysis, traffic volume was in the period of 07.00-20.00. The traffic data are provided in Figure 3 which consists of trucks (2%), buses (3%), cars (95%).

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a) b)

Figure 2: a) Map showing the location of the studied intersection and b) Traffic volume at evening peak hour

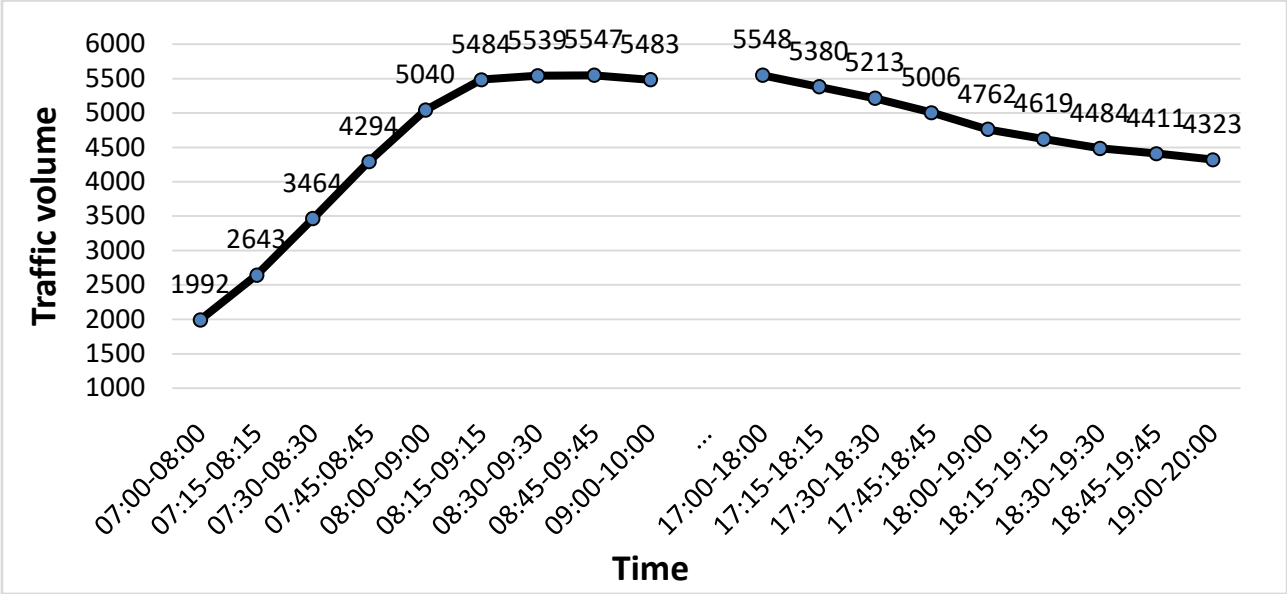

Figure 3: Traffic volume at evening peak hour

Traffic congestion is related with increased emission rate and fuel consumption at the intersection. Therefore, the obtained traffic data for emission modelling usually relies on the traditional approaches. Emissions are functional relationships of the traffic condition, expressing the quantity of a pollutant vehicles, distance, time or mass of fuel burned. The vehicles give an important contribute to air pollutions, overall in respect of Carbon Dioxide (CO2), Hydrocarbons (HC), Carbon monoxide(CO), Nitrogen oxides (NOx) and volatile organic compounds (VOC).Emission data is expressed in grams of pollutions per kilometer. In general, exhausted emissions from vehicle can estimated following equation:

$$Emission = E_f \cdot d$$

Where, E_f –relative emission factorand d–vehicles traveled distance.

Traffic signal is accepted the traffic control for the congested intersections and using this form of queueing with an arrival rate (λ) and a departure rate (μ). Maximal number of vehicles in queue can be found as $Q = \lambda \cdot r$.

Queue can be computed following formula:

$$T_{queue} = \frac{\rho \cdot r}{1 - \rho}$$

Where, T_{queue} – Time for queue to empty, r – red time and $\rho = {}^{\lambda}/_{\mu}$.

Delay can be found with perception of arrival rate, departure rate and red time. Total delay is product of all queues in the time period and maximum delay is equal to red time. Average vehicle delay per cycle can be found such as:

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$$D_{avg} = \frac{r^2}{2 \cdot C \cdot (1-\rho)}$$

Average delay per vehicle due to uniform arrivals can be calculated as:

$$d_{avg} = \frac{0.5 \cdot C \cdot \left(1 - {}^{g}/_{C}\right)^2}{1 - \left[\min(1, X)\frac{g}{C}\right]}$$

Where C- cycle length, X= Volume/Capacity (v/c) ratio.

Level of service of the intersection is estimated based on the methods of HCM [30] as shown in Table 1.

Table 1: Level of service for signalized and unsignalized intersections

LOS	Signalized	Unsignalized
	(second)	
A	≤ 10	≤ 10
B	> 10 – 20	> 10 – 15
C	> 20 – 35	> 15 – 25
D	> 35 – 55	> 25 – 35
E	> 55 – 80	> 35 – 50
F	> 80	> 50

IV. Results and Discussions

a) Existing condition

Details of the design of the intersection is presented, two major streets (Shota Rustaveli and Shakhrisabz streets) have 4 lanes in each direction, Mirabad minor streets have 3 lanes in each direction, and the circular island in the central part of the intersection has a diameter of 42 m. The maximum allowed speeds of vehicles on the roads of the city is 70 km/h.Based on the analysis the observations result of the phase timing and signal phase can be given in Table 2 and Figure 4. Signal cycle length is 90 seconds.

Table 2: Phase timing

Phase	Green period (sec)		
	Start time	End time	Duration
A	3	44	41
B	3	44	41
C	56	82	26
D	56	82	26
E	3	44	41
F	56	82	26
G	49	82	33
H	49	82	33
I	3	42	39
J	56	82	26
K	3	42	39
L	87	42	45

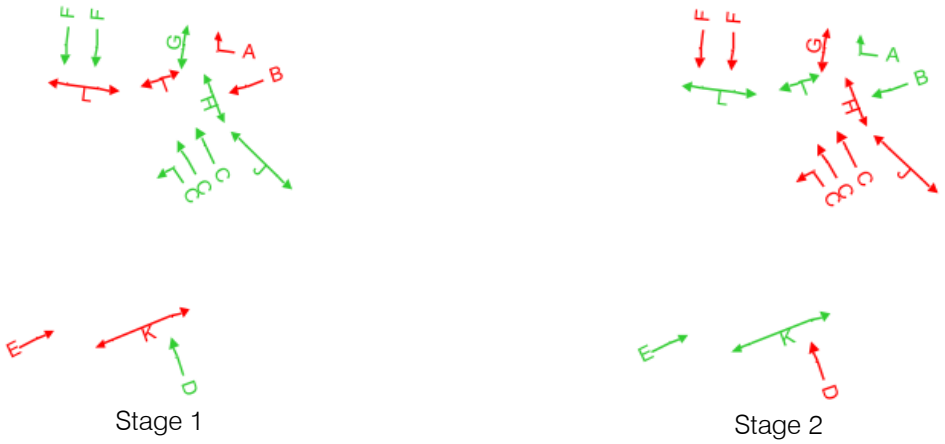

Figure 4: Stage sequence diagram for Controller flow

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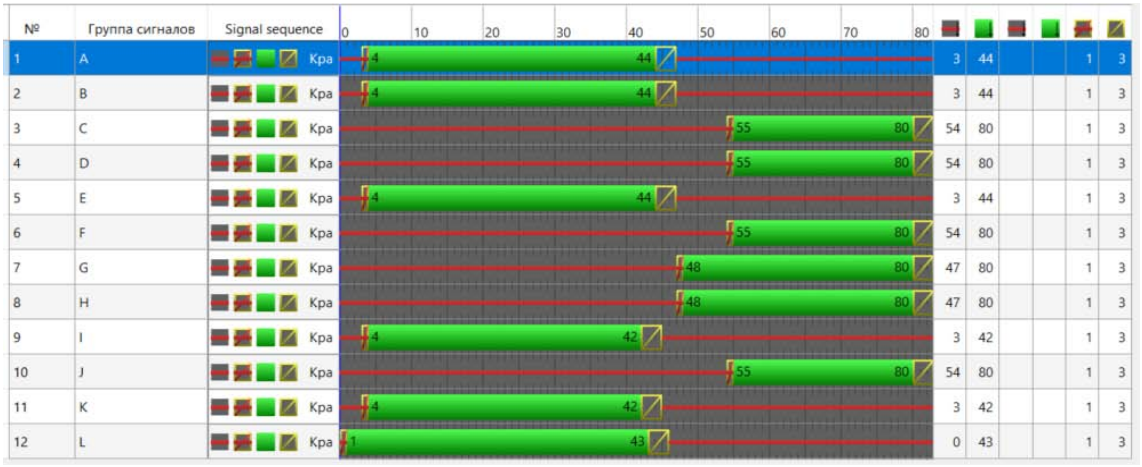

Figure 5: The existing signal phases in vissim

The simulation using PTV vissim for the existing conditions were obtained a level of service (LOS) C with a delay of21.61 seconds/vehicle. Major significant parameters were shown in Table 3.The level of service was similar with the existing condition however the congestion time increased 23 percent in 2022 and 275 percent in 2025.

Table 3: The analysis results of intersection for the existing condition and future

№	Parameters	2020	2022	2025
1	Level of service (LOS)	C	C	E
2	Vehicle delay (sec)	21.61	26.68	59.25
3	Queue length (m)	16.55	28.28	93.9
4	Maximum queue length (m)	83.35	119.23	231.42
5	All stops	0.74	0.94	2.65
6	All vehicles	5509	6245	7155
7	Emission CO (gram)	7993.22	10019.28	20583.15
8	Emission NOx (gram)	1555.19	1949.39	4004.73
9	Emission VOCs (gram)	1852.506	2322.067	4769.884
10	Fuel consumption (liter)	423.1	530.35	1089.52

Currently, more than 0.5 mln vehicles are registeredat Tashkent and an average of several hundred vehicles are coming and leaving the city per day. Dynamic relations of daily traffic are unknowable. The analysis shows that an average more than 55,000 vehicles are observed at the intersection daily. Traffic engineers use projection of future traffic to make recommendations and decisions on transportation investments each year.Most traffic projection models rely on linearprojections of past traffic counts. By the traffic modeling using a PTV vissim model is to be analyzed the performance of parameters of the intersection. Separate analysis and evaluation are required in cases where traffic flows may vary significantly during rush hour in the morning and afternoon. The linear increment (cumulative) method was used to predict traffic flow. It was calculated traffic flow projection with 7% growth rate per year in Table 4.

Table 4: Traffic flow projection

Йил	Hourly traffic volume(with growth rate 7%)
2020	5500
2022	6200
2025	7700
2030	10800

b) First alternative for improving intersection performance

The intersection improvement by applying the first alternative was carried out by redesigning the green time interval and optimization with computer PTV vissim simulation. The results areas shown in Table 5. The modelling results of the first alternative were defined a level of service B with a delay of 16.06 seconds/vehicle. The level of service was not similar with the existing condition and vehicle delay time decreased 25 percent.

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In general, there was an improvement for the intersection performance to the existing condition. In 2030, Travel time cannot be predicted that traffic flow with same 7% growth rate, in which the traffic volume approaching exceeds capacity, LOS F is characterized by stop and go, low comfort and convenience.

Table 5: The analysis results of intersection performance for the first alternative

№	Parameters	2020	2022	2025	2029	2030
1	Level of service (LOS)	B	B	C	E	F
2	Vehicle delay (sec)	16.06	16.76	20.13	72	89
3	Queue length (m)	10.91	13.43	22.42	125.82	146.3
4	Maximum queue length (m)	66.06	84.81	132.46	231.46	231.5
5	All stops	0.56	0.59	0.74	3.56	4.58
6	All vehicles	5518	6295	7607	9202	9198
7	Emission CO (gram)	7130.6	8225.4	10890.8	32002.5	38512.9
8	Emission NOx (gram)	1387.4	1600.4	2118.9	6226.5	7493.2
9	Emission VOCs (gram)	1652.58	1906.3	2524.1	7416.9	8925.8
10	Fuel consumption (liter)	377.4	435.4	576.5	1694.1	2038.6

c) Second alternative for improving intersection performance

The improvement of intersections for the second alternative was carried out by redesigning from roundabout to channelized intersection in same conditions such as traffic volume, number of right and left turn vehicles at intersection, number of lanes, number of pedestrians and traffic signal length.

The analysis results of the redesigning intersection performance are shown in Table 6. Based on the results of the second alternative, the LOS was obtained B with a delay of 12.08 seconds/vehicle. It means there was an improvement of the intersection performance results from the second alternative solution.

Table 6: The analysis results of intersection performance for the second alternative

№	Parameters	2020	2022	2025	2026	2027
1	Level of service (LOS)	B	B	D	E	F
2	Vehicle delay (sec)	12.08	17.04	42.55	75.86	81.1
3	Queue length (m)	6.13	11.18	36.48	61.49	69.66
4	Maximum queue length (m)	80.89	107.28	193.45	257.35	257.42
5	All stops	0.49	0.71	1.81	3.5	3.6
6	All vehicles	5486	6236	7122	7176	7150
7	Emission CO (gram)	6064.1	8263.1	17111.2	28497.6	29399.6
8	Emission NOx (gram)	1179.8	1607.7	3329.3	5544.5	5720.1
9	Emission VOCs(gram)	1405.4	1915.1	3965.7	6604.6	6813.7
10	Fuel consumption (liter)	321	437.3881	905.7452	1508.457	1556.2

d) Comparison of the results

Based on the analysis performance parameters of intersection, the firstalternative is the best option for improving intersection performance. It reduced delay, shortened vehicle queue time, reduced queuing volume of vehicles, thereby reduced the traffic congestion as well as increased the LOS at the signalized intersection. The result also showed that the delay was reducing from 21.61 seconds/vehicle to 16.06 seconds/vehicle, vehicle queuing length from 83.35 seconds to 66.06meters, and intersection LOS increased from C to B. It means that the second alternative can reduce the traffic congestion by 25 percent and then improve the intersection performance significantly. Fuel consumption can also decreased by 25 persent. A detailed comparison of the results is shown in Table 7.

Table 7: Comparison of results for existing condition and alternatives for 2020 year

№	Parameters	Existing condition	1st alternative	2nd alternative
	Level of service (LOS)	C	B	B
	Vehicle delay (sec)	21.61	16.06	12.08
	Queue length (m)	16.55	10.91	6.13
	Maximum queue length (m)	83.35	66.06	80.89
	All stops	0.74	0.56	0.49
	All vehicles	5509	5518	5486
	Emission CO (gram)	7993.22	7130.6	6064.1

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	Emission NOx (gram)	1555.19	1387.4	1179.8
	Emission VOCs(gram)	1852.506	1652.58	1405.4
	Fuel consumption (liter)	423.1	377.4	321

V. Conclusions

The assessment of the intersection was performed by important parameters such as considering delay, queue, fuel consumption, amount of pollutantsand level of service. The analysis showed the existing condition at the intersection was stable flow with average delay of 21.61second/vehicleand LOS -C.Two alternatives to improve the intersection performance were investigated using Vissim 20: Alternative 1 and Alterative 2. The first alternative was re-designing green time of traffic light and the second alternative were consisted of re-designing green time and changed type of intersection. The 1st alternative obtained LOS of F in 2030 year, average delay of 89 second/vehicle, queue 231.5 meters. The 2nd alternative resulted performance was increasing with average delay of 81.1 second/vehicle, maximum vehicle queue 257.42meters and LOS of F in 2027 year. Alternative 1 is considered the best solution, this option will reduce delay by 25 %, queue by 21 %, decrease the congestion cost by 25 %, and increase LOS. In general, the 1st alternative improves the intersection performance significantly for long period of time. Based on the computer modeling results in all three conditions, the second scenario is the best option with optimization of traffic signals with the PTV vissim simulation software.

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Assessing the Determinants of Open Defecation Free Communities based on the Socio-Demographic and Economic Status of Household Heads in the Mion District of Northern Region, Ghana

By Abdul-Rahaman Issahaku, Osman Alabira & Adam Wahabu

University for Development Studies

Abstract- The study was conducted in twenty open defecation free communities of the Mion District in the Northern Region with the objective of assessing the determinants of open defecation free communities based socio-demographic and economic status of household heads correlational analysis. The study design was mainly quantitative and involved225 respondents. The study found that, 73.4 percent have hand washing facilities for washing their hands after defecating but no soap, 62.2 percent of the respondents indicated had hand washing facilities, water and soap. The correlation analysis shows that there was a relationship between household size and open defecation free communities (p=0.000), age of respondents and open defecation free communities (p=0.000), religion and open defecation free communities (p=0.000) and the presence of water at toilets and open defecation free communities (p=0.017).

Keywords: climate change, household toilets, open defecation, sanitation, water resources.

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Assessing the Determinants of Open Defecation Free Communities based on the Socio-Demographic and Economic Status of Household Heads in the Mion District of Northern Region, Ghana

Abdul-Rahaman Issahaku [α], Osman Alabira [σ] & Adam Wahabu [ρ]

Abstract- The study was conducted in twenty open defecation free communities of the Mion District in the Northern Region with the objective of assessing the determinants of open defecation free communities based socio-demographic and economic status of household heads correlational analysis. The study design was mainly quantitative and involved225 respondents. The study found that, 73.4 percent have hand washing facilities for washing their hands after defecating but no soap, 62.2 percent of the respondents indicated had hand washing facilities, water and soap. The correlation analysis shows that there was a relationship between household size and open defecation free communities (p=0.000), age of respondents and open defecation free communities (p=0.000), religion and open defecation free communities (p=0.000) and the presence of water at toilets and open defecation free communities (p=0.017). The relationship between the use of soap and open defecation free communities could not be determined (p=0.050). Eighty-four(21.3%) percent of the respondents indicated that the high cost of constructing toilets was the reason why they had no household toilets. Other factors why toilets were not constructed in homes were lack of technical support (14.7%), waiting for external support (33.3%) and the notion that household toilets were not necessary (30.7%).The study concludes that the determinants of open defecation free communities in the Mion District are age, household size, religion and belief systems, and the presence of water and income of residents. The study recommends that governmental and nongovernmental agencies in water and sanitation must support the aged and the poor to construct household toilets. All agencies supporting water and sanitation must harmonize their activities on community led total sanitation and further education and sensitization is necessary to ensure that communities that attained open defecation free status do not relapse into open defecation.

Keywords: climate change, household toilets, open defecation, sanitation, water resources.

Author α: Dry Lands Research Institute, University for Development Studies, Tamale, Ghana. e-mail: irahaman2@uds.edu.gh
Author σ: Environmental Health and Sanitation Unit, Regional Coordinating Council, North East Region, Ghana.
Author ρ: Environmental Health and Sanitation Unit, Regional Coordinating Council, Savanna Region, Ghana.

I. Introduction

Globally, achieving good sanitation has remained a mirage. Nearly 2.5 billion worldwide have no access to improved sanitation (WHO/UNICEF, 2006; WHO/UNICEF, 2013); 946 engage in open defecation WHO/UNICEF, 2015) and over 780 million have no access to improved drinking water (WHO, 2006). As a result, the United Nations calls for ending open defecation and universal access to adequate and equitable sanitation in the Sustainable Development Goals (SDGs) (UN General Assembly, 2015). These have become a challenge in developing countries as over 80 percent of diseases are due to poor sanitation (WHO/UNICEF, 2006) and cause the death of one and a half million death in children under 5-years (WHO/UNICEF, 2013).

In Ghana, nearly 28.0 percent of the population has no access to good sanitation (Plan International, Ghana, 2013). Northern Region in Ghana is poor in sanitation. In 2006, it was reported that nearly 73 percent of the population were engaged in open defecation with over two metric tonnes of human excreta generated daily. Most of the inhabitants are farmers and use human excreta to fertilize their farm lands or are disposing away in the open fields (Plan International, Ghana, 2015). This is because; the engineering land field site is only in the regional capital Tamale and most households depend on public toilets.

It was therefore important to introduce Community Led Total Sanitation (CLTS) to improve sanitation in rural districts who have no household toilets to protect them from sanitation related diseases, poverty and death. CLTS was first introduced in Ghana in the towns of Mankessim, Asesewa and Bawjiase in the Central Region in 2006 by the Community Water and Sanitation Agency (CWSA) and was later supported by Plan International Ghana (Plan International Ghana, 2013) and United Nations Children Emergency Fund (UNICEF) to scale up in 2010. As CLTS gained recognition of success, the Government of Ghana

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(GoG) revised the National Sanitation Policy of 1999 (Ministry of Local Government and Rural Development (Plan International, Ghana, 2013)to update its scope and to address the underlying causes of poor sanitation and improve the health of the citizens. The national environmental and sanitation policy in Ghana had a co-ordinating council mandated to acquire and protect lands for the purpose of treatment and disposal of waste; to encourage public and private developers to factor waste management in their developmental plans; to streamline the cost and payment of sanitation services; ensure the ownership of household toilets; to introduce environmental and sanitation day that will be celebrated once a year and to established bylaws to regulate sanitation and prevent pollution in their districts (Plan International, Ghana, 2015). GoG also adopted the CLTS approach as a national strategy for expanding sanitation and hygiene practices, and developed an open defecation free (ODF) protocol for assessing communities' ODF status, and systems of award and recognition of ODF communities. Factors that enabled the implementation of CLTS and which could contribute to its sustainability in Ghana are supportive government policies and strategies and national guidelines for CLTS implementation, and CLTS coordinating committees (Crocker and Bogle, 2015).

CLTS is a relatively new approach, with both opportunities and challenges. CLTS may not be sustainable (Guiteras et al., 2015) as it is appropriate in high baseline open defecation (Crocker et al., 2016) and high social capital (Cameron et al., 2015). CLTS is more sustainable where there is a supportive enabling environment such as sufficient follow-up visits, market-access to latrine products and materials and socially cohesive of communities (Hanchett et al., 2011; Mukherjee et al., 2012; Tyndale-Biscoe et al., 2013;Cavill et al., 2014). There is limited literature on the impacts and sustainability of CLTS (Garn et al., 2016), and creating longer term reports on sanitation impacts is a new research priority (Waddington et al., 2009).

The concept of CLTS began in the year 2000 and has since being adopted by over 60 countries including Ghana. These countries have included CLTS in their national policies (Institute of Development Studies, 2016). CLTS appealed to strong emotions such as self-respect, shame and disgust. A central tenet of the approach is that behavior change occurs when emotional responses are combined with cognitive understanding. CLTS uses three main triggers to bring about behavior change. Direct observation of defecation practices, hands-on demonstration and handling of feces provoke shame and disgust when participants realize that feces can get into the body through the mouth. If this trigger is effectively executed, a collective sense of urgency for change is created. Instead of focusing on households, CLTS creates a collective sense of disgust and uses peer pressure to generate a need for collective action. CLTS uses public, visual monitoring of achievement and recognition of successes. It maintains the momentum of change by motivating pride and competition to boost the household's commitments in public. A potential weakness of CLTS is that the effectiveness of the triggering process depends on external factors such as the quality of the facilitation, and the degree of participation by the community (Crocker et al., 2016).

The benefits of CLTS include not having to go out before dawn or after dark, safety from the associated risks of violence and sexual abuse, time saved and less embarrassment (Crocker and Bogle, 2015). As a result of these benefits, several agencies collaborate in implementing CLTS in rural communities. Among them are UNICEF, USAID, SNV Netherland Development Organization, Global Communities, Water Aid Ghana, World Vision International, and local organizations such as Pres by Water, Catholic Relief Services (CRS) and Afram Plains Development Organization (APDO). CLTS is participatory and generally includes capacity building in addressing open defecation (Kar and Chambers, 2008; Pickering et al., 2015). Their successes have been the provision of water, sanitation and hygiene through participatory rural appraisal (PRA) techniques (Crocker et al., 2016). In CLTS the communities understand that the process is a shift towards a zero subsidy approach rather than providing them with money to construct latrines.

In earlier studies by Crocker et al., (2016) in Ghana, it was found that open defecation has decreased in CLTS implemented communities. Also, health extension worker-facilitated CLTS performed better than teacher-facilitated CLTS in Ethiopia (Crocker et al., 2016).It is reported that the Northern Region ranks third highest among ten Regions with 72.9 percent open defecation. Since the inception of CLTS in the Northern Region, many interventions have been made and the Mion District is at the verge of attaining district's wide ODF status. However, no impact study has been conducted to assess its successes and sustainability. The study therefore intends to assess the determining factors of achieving ODF status using socio-demographic and economic status of household heads in the Mion District.

II. Study Area and Methodology

a) Study Design

The study employed the use of quantitative technique to collect the data. Quantitative research is a formal, objective and systematic process in which numerical data is collected and utilized to obtain information about the work. Structured questionnaires were used for the quantitative data (JMP, 2012)and confirmed by observation and interview with staff of the Mion District Assembly using the indicators below:

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Cleanliness of the latrine;

Existence and condition of hand washing facilities;

Refuse site management;

Safe disposal of waste water from bathrooms and kitchens;

Management of shrubs and bushes around the community (OD risk);

Compliance with Community Action Plans;

Updated Community Defecation Map/extended to maps tracking other hygiene practices;

Availability of community-enforced by-laws and sanctions e.g. against open defecation;

Food hygiene and safety practices appropriate to local lifestyle;

Household water safety;

Proper disposal of animal waste/ confinement of animals;

Water source protection;

Availability of sanitation and hygiene products and services desired by consumers and

Availability of financing for consumers and suppliers.

Source: Joint Monitoring Programme for Water Supply and Sanitation (JMP) (2012

b) Study Area

The Mion District Assembly was established on 6th February, 2012 by LI 2064 and was officially inaugurated in June 2012 as one of the Forty-six (46) newly created District Assemblies in Ghana. The capital of the district is Sang. The Mion District is located in the eastern corridor of the Northern Region of the Republic of Ghana between latitude 9^0 – 35^0 North and longitudes 0^0 – 30^0 West and 0^0 – 15^0 East. The District shares boundaries with Yendi Municipal to the East, Tamale Metropolis and Nanton District the West, Gushegu and Karaga to the North and Nanumba North and East Gonja Municipal to the South. The distance from the district capital Sang, to the regional capital, Tamale is about 63km.

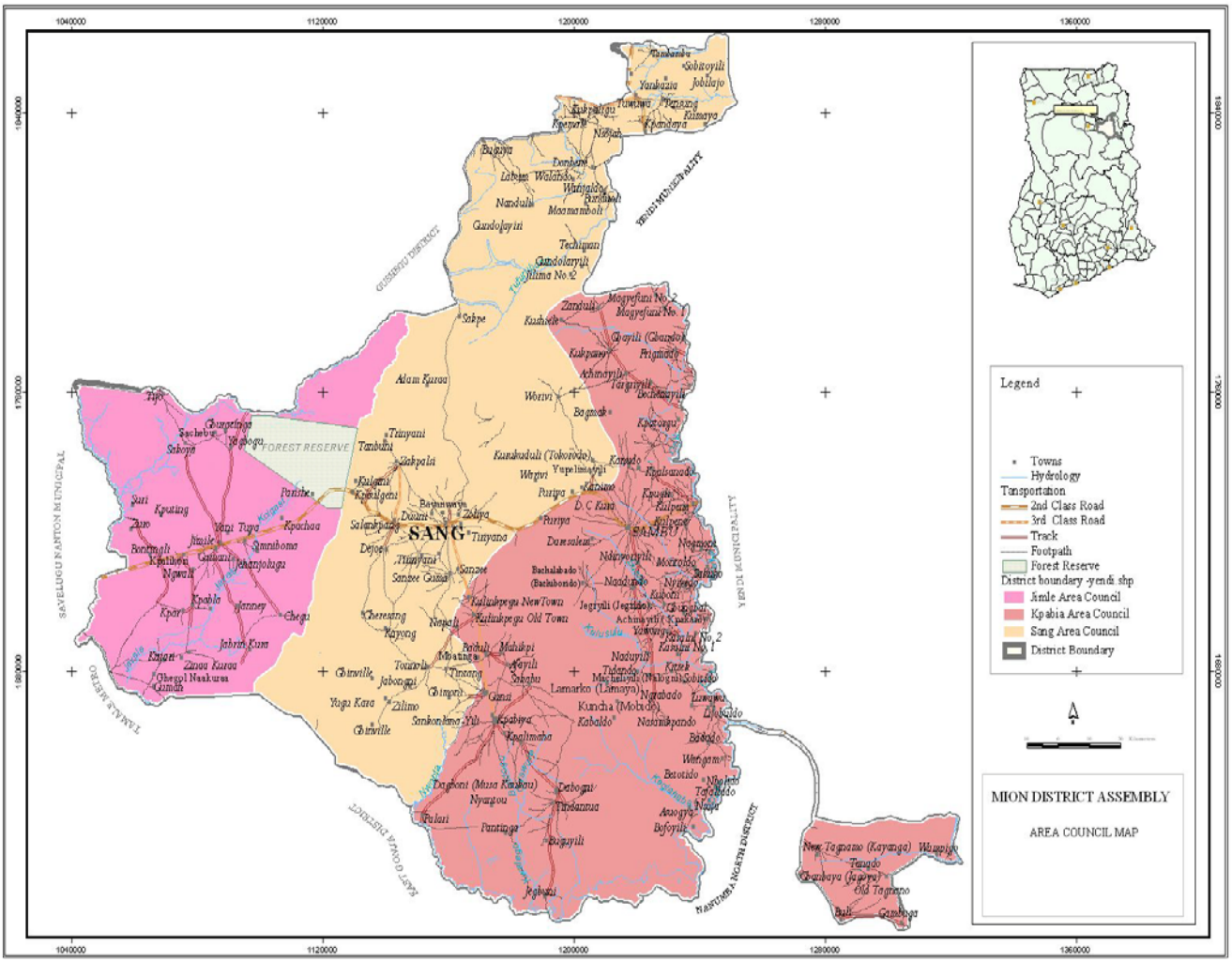

Figure 1: Map of Mion District

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The District covers a surface area with a landmass of 2,714squarekilometres. There are three (3) Area Councils in the District Namely Sang, Kpabia, and Jimle. The District has 20 Electoral Areas and 171 communities. Mean annual rainfall for the district is 715mm. The raining season rainfall for the district is from April to October while the dry season is from November to March. Temperature ranges between 21^0C- 40 ^{0}C giving rise to high temperature range. The climate of the district is the guinea savannah type. The degraded savannah type of vegetation is found around settlements and heavily cultivated areas. The rampant and extensive bush burning is having an adverse effect on the vegetation and consequently the climate. High temperatures make the environment uncomfortable for both biotic and abiotic organisms to function effectively. Economic trees in the district include Shea trees, Dawadawa, Mango and Cashew.

The rock type is sedimentary and predominantly voltarian sandstone, shales and mudstones. The soils derived from the rocks range from laterite, ochrosols, sandy soils, alluvial soils and clay. The organic content of the soils is low and increasingly worsened by the extensive bush burning and bad agricultural practices. This to a large extent accounts for the low yield per acre of crops and its consequent food shortage during the dry or lean season in the district.

The population of the District is 81,812 (GSS, 2012) and is varied in terms of ethnicity with the Dagomba constituting the majority. The other ethnic groups include Konkomba, Akan, Ewe, Basare, Moshie, Chokosi and Hausa. The population is largely rural. About 92.0% live in the rural areas while 8.0% are in towns. The population growth rate is approximately 2.9% per annum. Some of the major towns in the District include: Sang, Sambu, Jimle, Kpabia, Zakpalsi and Sakpe. The main religious groupings are Moslems, Christians and Traditionalists. Migration pattern is more pronounced among the youth and especially female girls who basically travel down south to engage in menial jobs popularly called 'Kayaye'. Out migration by young girls exposes them to all forms of sexual abuse and low female school enrolment or high dropouts.

The state of environmental sanitation in the district is improving; however, a lot more needs to be done. Out of the total refuse generated, about 51% of it is collected but not dispose of properly. Meanwhile, most houses in the high density areas lack toilet facilities and drains.

With regard to excreta disposal management, the 2014 regional analysis of the 2010 population and housing census indicates that, 41.6% of the population in the district have access to improved toilet due to the implementation of the Community Led Total Sanitation (CLTS) whiles 58.4% are sharing and use unimproved sources of toilet such as public toilet (GSS, 2014).

c) Sample Size

The total households of Mion District stand at 7,139 and the average household size is 9.3 and there are three (3) Area Councils in the District namely Jimle, Sang and Kpabia (GSS, 2012). A sample size of 225 was selected from each of the area councils.

d) Determination of Sample Size

This study employed multiple stages. First of all, simple random sampling was used to select 20 ODF communities from the Mion District Assembly for the study (Table 1). These communities were selected because they were part of those communities in which community led total sanitation (CLTS) is been implemented in the district and therefore have knowledge regarding the implementation of the CLTS and what open defecation free (ODF) communities are. Also, these communities were selected because of the willingness of the community members to respond to the survey questionnaire and above all the accessibility of the researcher to the community leaders to assist in the mobilization of the heads of households.

Secondly a formula for determining sample size given by (Krejcie and Morgan, 1970) was used to determine the sample size of 225 respondents from a population of 542 household heads. Thus:

$$S=X^2NP(1-P)/d^2(N-1)+X^2P(1-P) \ldots \quad \ldots(1)$$

Where:

S=required sample size

X^2= The table value of Chi-square for 1 degree of freedom at desired confidence interval (3.841 or 1.96×1.96)

N=the population size=542

P=the population proportion (Assumed to be 0.5 since this would provide the maximum sample size)

d=the degree of accuracy expressed as a proportion (0.05). From the information above;

$S=3.841(542)(0.5)(1-0.5)/(0.05)^2(542-1)+(3.841)(0.5)(1-0.5)$

$S=520.4555/1.3525+0.96025$

$S=520.4555/2.31275$

$S=225.0375$

$S=225$

Thirdly, the sample size of 225 respondents was proportionally distributed to the communities based on the total number of households as given by the Mion District Assembly. The sample frame and the sample size of the communities are shown in table 1.

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Table 1: Sampling Size in various communities

Name of Community	Total Household	Sample size
Jilma No.1	26	11
Jibilajo No.2	53	22
Nkwanta	18	7
Kpumale	35	15
Wasambo – B	27	11
Macheliyili	43	18
Kubagmado	12	5
Frigmado	22	9
Tuya	21	9
Namoni	18	7
Binagmando	24	10
Motondo	23	10
Sobitido	35	15
Nayinkundo	18	7
Kuboni	39	16
Bungbali	33	14
Yawondo	30	12
Bichado	28	12
Chirizang	19	8
zanduli	18	7
Total	**542**	**225**

Source: Field survey, 2020

Finally, the survey questionnaire was tested and mistakes corrected in other communities of the Mion District which were not part of the study communities.

e) Sampling Procedures

For the survey, the target population was made up of households in Mion District. As Curtis (1998) suggests, it is necessary in hygiene studies to focus on households because this is the level at which internal and external processes come together to produce health. In this regard, the concept of household was used as defined in the 2010 Population and Housing Census. For this census, a household was defined as a person or group of persons who live together in the same dwelling, share the same house-keeping arrangements and are catered for as a unit (GSS, 2012). By this definition, family members may not necessarily be household members based on their living arrangements. In the same vein, not everyone who lives in the same house can be defined as constituting a household. Further, length of time of stay of members was considered as some may just be visitors to the house and may not necessarily be permanent members of the household. Therefore, the study, focused on people who live in the same house and eat from the same pot and have access to the same facilities in the house at least six months before the study.

A complete sampling frame obtained from the District Assembly was used to select households to be included in the study. From this list of 542 households obtained from the district assembly, 225 households were chosen using the simple random sampling technique. Numbers were assigned to each household in the list and using the lottery method the numbers were picked till the sample size was obtained. The simple random technique ensured that every unit in the population had an equal chance of being picked for the study. It also provided a sample of people who live in the same community but occupy different types of houses and use different types of toilet facilities. This survey targeted household heads but in their absence any adult (18 years and above) who was found within the household was interviewed. For the selected staff of the NGOs, and the District Assembly purposive sampling was used because of their in-depth knowledge with regards to the subject matter at hand.

f) Pre-data collection procedures

Community entry can be very difficult without the use of social connections; therefore, it was necessary to contact as many relevant people as possible. This was also necessary not only to gain access to the community, but to erase as much as possible suspicion in the minds of the people. It also fostered a better understanding of the ways in which issues are handled, especially those pertaining to the study. The community entry was facilitated by the District Environmental Health Officer (DEHO) of the Mion District Assembly. The DEHO often conducts monitoring and supervision of his staff in the communities so he is popular among the people. This goodwill was further enhanced when natives who are part of the implementation (Natural leaders) in each of the communities were made translators for the study; community entry process was made fairly easy.

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The researcher began data gathering in 2020 by first training four Assistant researchers and also familiarizing himself with the field. This was done by identifying and establishing rapport with key informants. These key informants were mostly suggested through formal and informal discussions with some of the community members. The first persons to be contacted were the assembly persons for the communities who represent the political authority at the community levels or electoral areas. They were contacted to give permission for the conduct of the study and to seek their assistance in identifying people whose views could be of immense help to the study. After explaining the intent and purpose of the study, the chiefs of the communities were met.

g) Data Collection

The study collected both primary and secondary data. The primary data was collected using a structured questionnaire at the household levels using a survey guide. The Secondary data was collected from registers of monitoring tools, quarterly reports, review reports, annual reports and plans of district and regional environmental health and sanitation unit offices so as to compare with primary data collected. The quantitative data was collected using questionnaire, which was designed as the result of intensive literature search, programme theory and conceptual framework of the pre-determined questions and responses. After numbering the households the questionnaire was administered to all heads of households selected for the study. In case of those selected household heads were absent another person who is 18years and above was selected. During data collection the head of households were requested for their consent to participate in the study.

h) Data Processing and Analysis

The data was checked for distribution and outliers. The questionnaire was coded and entered using Statistical Package for Social Sciences (SPSS) version 20; descriptive statistics was done to derive numerical and non-numerical data presentation models including, graphs and tables. The data was also analysed using correlation to find the relationship between socio-demographic data and open defecation free communities to established the determinants of open defecation.

III. Results and Discussion

a) Socio Demographic Characteristics of Respondents

Information on the socio-demographic information of the respondents included both males and females. The least age of the respondents was 18 years with a maximum age of 60 years. There were a total of 225 respondents who responded to the structured questionnaire. Out of this, 170 were males representing 75.6 percent of the respondents and 55 females representing 24.4 percent of the respondents (Figure 2).

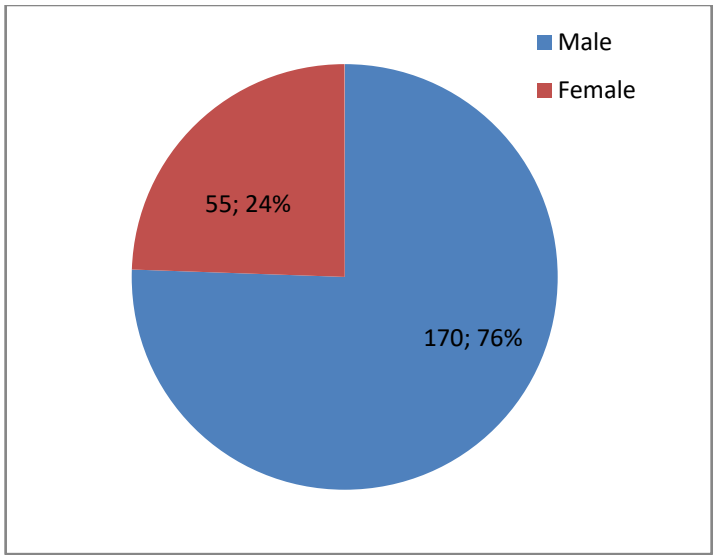

Figure 2: Sex of respondents. Source; Field survey, 2020

This is because; males are the household heads in the study district. The results showed that 29 respondents representing 12.9 percent of the respondents were between 18-25 years, 23.6 percent of the respondents were between the age 26-33 years, 21.3 percent of the respondents were between 34-41 years of age, 24.4 percent of the respondents were between 42-49 years of age, 12.9 percent of the respondents were between 50-57 years of age, whilst 4.9 percent of the respondents were 58-60 years of age (Table 2).

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Table 2: Age of respondents

Age group	Frequency	Percentage
18-25 years	29	12.9
26-33 years	53	23.6
34-41 years	48	21.3
42-49 years	55	24.4
50-57 years	29	12.9
58-60 years	11	4.9
Total	225	100.0

Source; Field survey, 2020

Also, on education the study revealed that 78.7 percent of the respondents have no formal education, 16.9 percent of the respondents completed primary/JHS, 3.1 percent of the respondents had SHS education, 1.3 percent of the respondents had HND/Diploma (Figure 3).

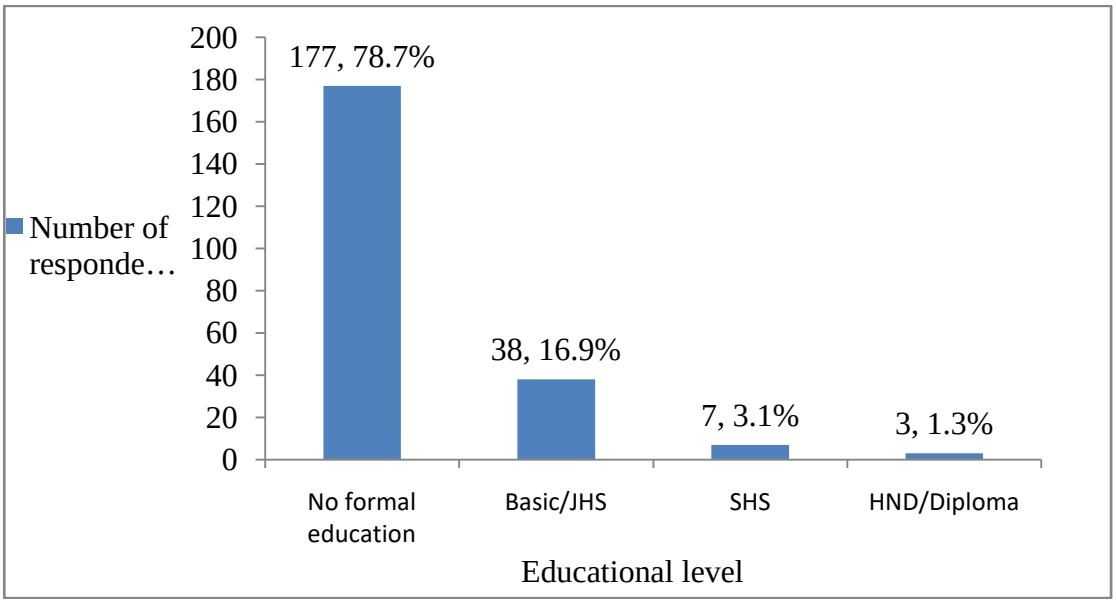

Figure 3: Educational level of respondents. Source; Field survey, 2020

On religion of respondents, the study revealed that 17.8 percent of the respondents were Muslims, 41.8 percent of the respondents were Christians, while 40.4 percent of the respondents were traditionalist (Figure 4).

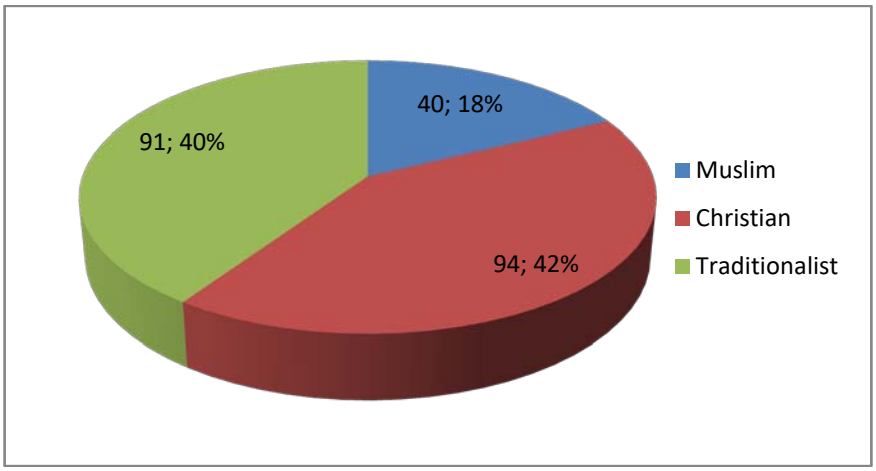

Figure 4: Religion of respondents. Source; Field survey, 2020

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On the occupation of respondent's 86.7 percent of the respondents were farmers,7.1 percent of the respondents were traders, 3.6 percent of the respondents were government workers, 2.6 percent of the respondents were unemployed as shown in Figure 5.

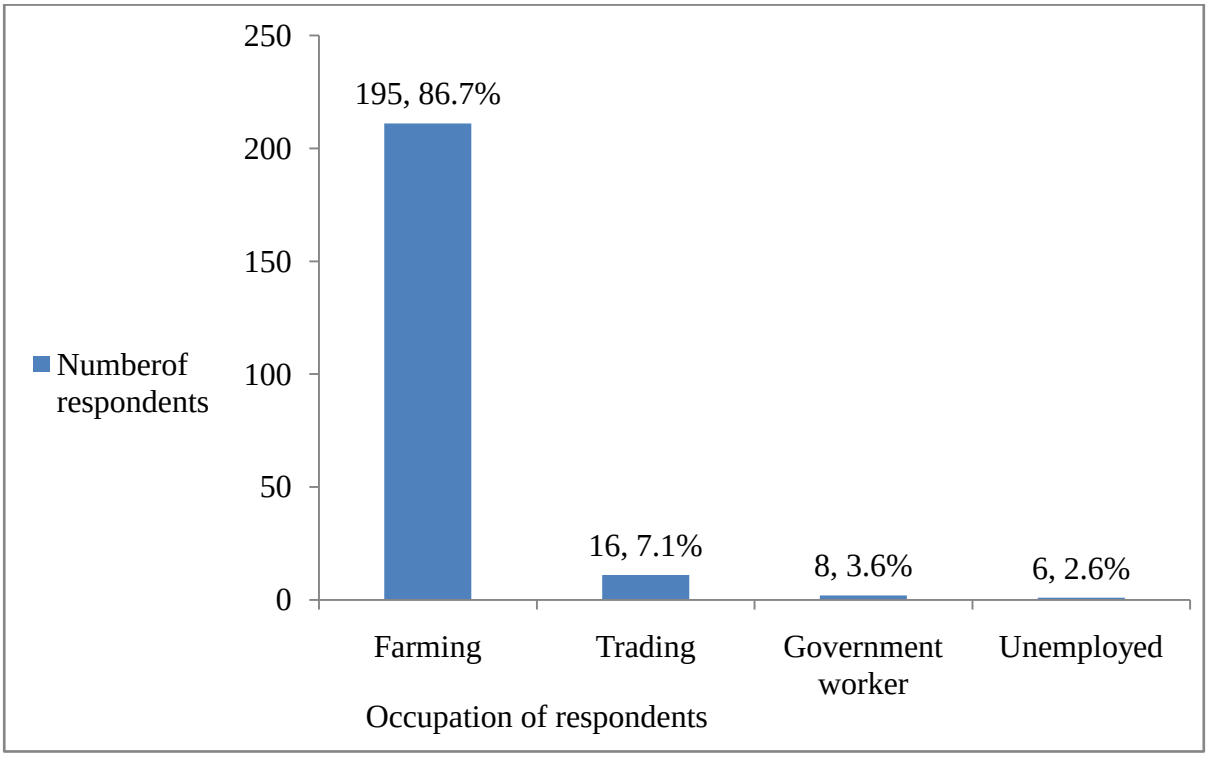

Figure 5: Occupation of respondents; Source: Field Survey, 2020

The dominance of farming in the Mion District is because the district is rural based. According to the Ghana Statistical Service, 92.0 percent of the district lives in rural areas. Abramovsky et al., (2016) observed that CLTS was effective in small, rural, homogenous communities as in the case of the Mion District.

b) Situational analysis of the implementation of Community-Led Total Sanitation (CLTS)

The study analyzes issues concerning the implementation of the CLTS in the Mion District in the Northern Region of Ghana. It looked at the income level of head of household and various sanitation issues that were raise with regards to the implementation of CLTS.

c) Household monthly income

The income earn by a household is a major factor in determining the social facilities that is provided in the household. The study looked at the income of the household heads per month, which revealed that 97.3 percent of the respondents earn <GHC500 per month while 2.7 percent of the respondents earn between GHC500-1000 per month.

d) Household size of respondents

The study indicates that 23.1 percent of the respondents have household size between 1-5 people, 36.4 percent of the respondents have household size between 6-10 people, 16.4percent of the households also have household size between 11-15 people, and 8.9percent have between 16 - 20 people. Also, 13.8percent of the respondents indicated that the number of people in their households were between 21-25 people, while 1.3 percent of the respondents have household size of over 26 people as shown in figure 6.

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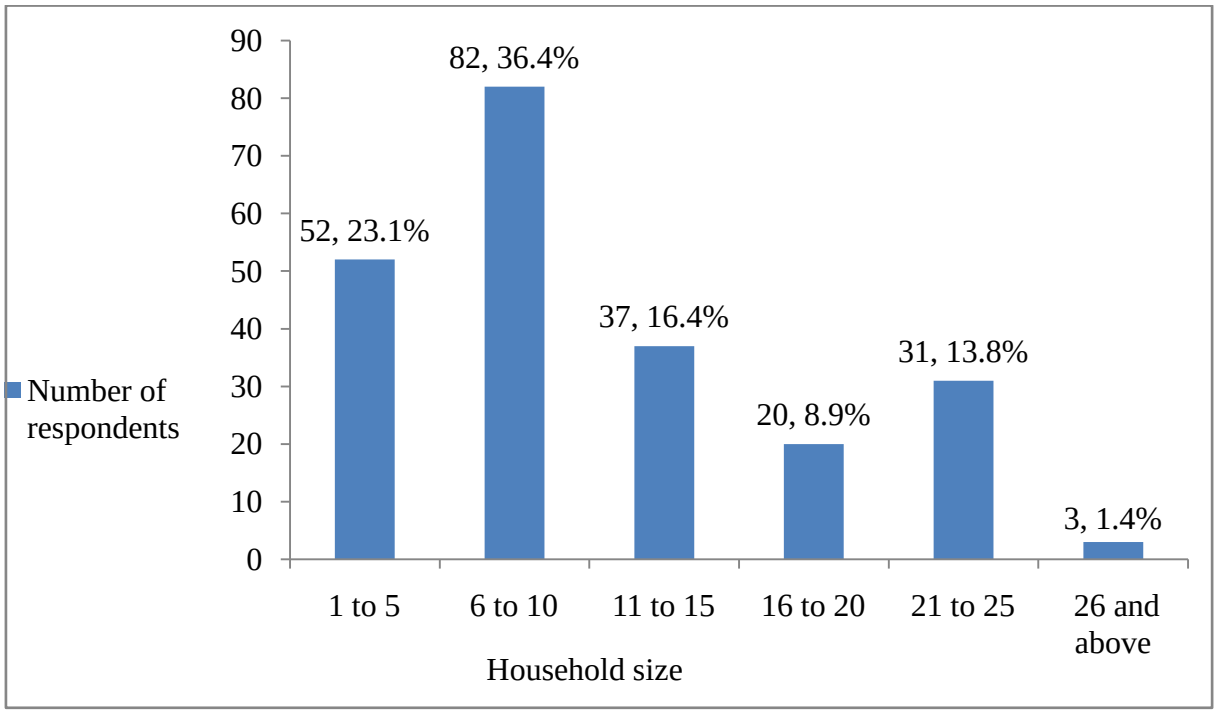

Figure 6: household size, Source: Field Survey, 2020

e) *Household Asset*

Nearly Eleven (11.1%) percent of the respondents own bicycles. Also 6.7 percent of the respondents own radio, while 8.9 percent of the respondents own Television (TV). The study further revealed that 17.8 percent of the respondents own farm animals whiles 26.7 percent of the respondents own farms.

The study showed that 4.4 percent of the respondents own motorbikes while 2.2 percent of the respondents own tricycles. Also 22.2 percent of the respondents own mobile phones(Figure 7).

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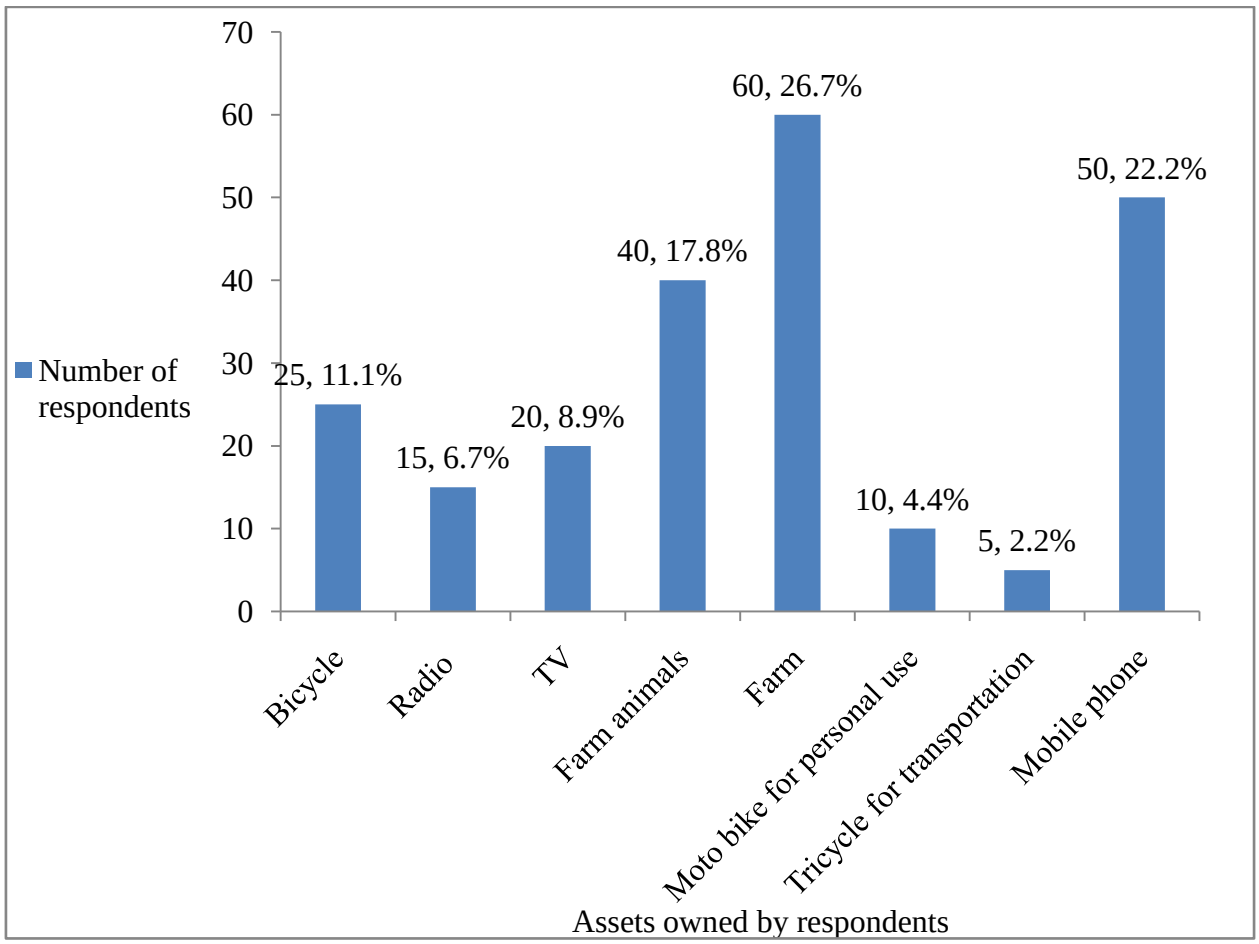

Figure 7: Assets of respondents, Source: Field Survey, 2020

f) Availability of Household Toilet

Also, on the question of households having toilets, the study revealed that as high as 94.1 percent of respondents were having household toilets, while 5.9 percent of the household do not own household toilet. This means that communities have more than the 80% thresh holds of household toilet coverage and were therefore open defecation free. The CLTS verification protocol states that a community can become ODF if 80% households have and use household toilets and the remaining 20% of households do not defecate in the open.

g) Cost of Household Toilet

The minimum amount needed to construct a basic toilet in 2012 ranged from US$35.00 for a basic pit latrine to US$180.00 for a VIP latrine (WASH Cost, 2012) but it is now US$283.33. Cheaper amount in the construction of latrines are at risks of long-term failure such as collapse of the super structure or substructures. If the cost of construction is high, most poor households and vulnerable groups like the aged and the destitute are unable to construct household latrines. The cost of building latrines vary because of variability in the US Dollar to Ghana Cedi rate and the variability in fuel prices in Ghana. Currently one US Dollar is five Ghana Cedis Seventy-nine pese was (1.00 US$=GHS 5.79) and the price of petrol for a litre is six Ghana Cedis, five pese was (GHS 6.05). The combined effect of these variables affects the cost of materials used for the construction of latrines at the households. For example, a bag of cement in the Northern Region is Fifty Ghana Cedis an equivalent of Eight US Dollars, Sixty-four cents (US Dollars 8.64) and a trip of sand is Five Hundred Ghana Cedis (US Dollars 86.36). These materials are important for the substructure. Other factors which are important and whose costs cannot be determined in the construction of a household latrine are cost of labor, building and constructional materials.

The survey on the type of toilet build by the households shows that 74.5 percent of the respondents build the traditional pit latrine, while 25.5 percent of the respondents build the improved pit latrine. This means that majority of the households in the communities build traditional pit latrine toilets in their houses.

h) Reasons for not having toilet in the household

The reasons given for not using toilets vary. The interview indicated that, they did not have money to construct household toilets. Others said they prefer

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using the bush while some said they were not comfortable defecating on another person's feces when they are not sick. From the survey, high cost of construction of the toilet was indicated by 21.3 percent of the respondents as the reason why they do not have a toilet in their house Again, 30.7 percent of the respondents attributed the reason why they didn't want to construct toilet as not important for them. A further 14.7 percent of the respondents indicated that lack of technical support is the reason why they do not have toilet facilities in their households. Additionally, 33.3 percent of the respondents indicated that they were waiting for external support as a reason why they do not have toilets in their household as shown in Figure 8.

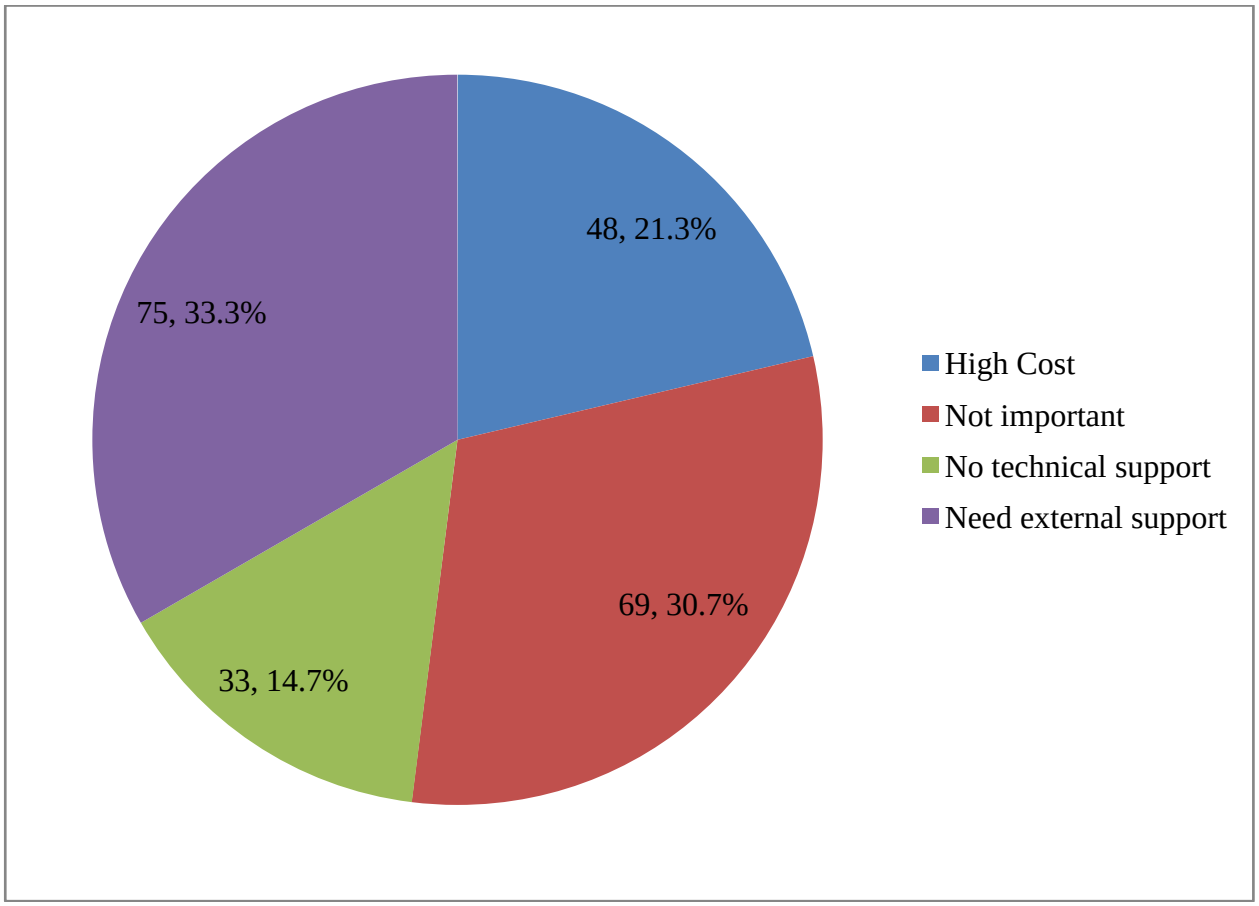

Figure 8: Reasons for not having toilet in the household, Source: Field Survey, 2020

This finding is similar to the finding of Barnard et al., (2013). Their study revealed that 72% of households had toilet which was increased by 10% when compared with control villages in India. According to Barnard et al. (2013), the main reasons for households not using toilet was that they prefer open defecation (29%). Also 20% said the toilets were inconvenient to them because of its smell, 23% said the toilets lack privacy, 17% said their toilets were blocked and 22% of the respondents use their toilets for storage purposes.

The survey looked at the availability of hand washing facilities and it was revealed that 73.4 percent of the respondents have hand washing facility for household members to wash their hands after defecating. The survey revealed that 62.2 percent of the respondents had hand washing facilities with soap for people who use their toilets to wash their hands. This implies that people will be protected from carrying diseases from their toilets to their food or for further transmission to other people in the community.

i) Source of Water for Households

The source of water for household is always a concern in the Mion district. The study showed that, most (31.5%) of respondents depend on dugouts for water, 22.2 percent of the respondents depend on river as a source of water for the household, 26.7 percent of the respondents depend on boreholes as source of water for the household, and 19.6 percent of the respondents depend on well as a source water for their household as shown in figure 7 below.

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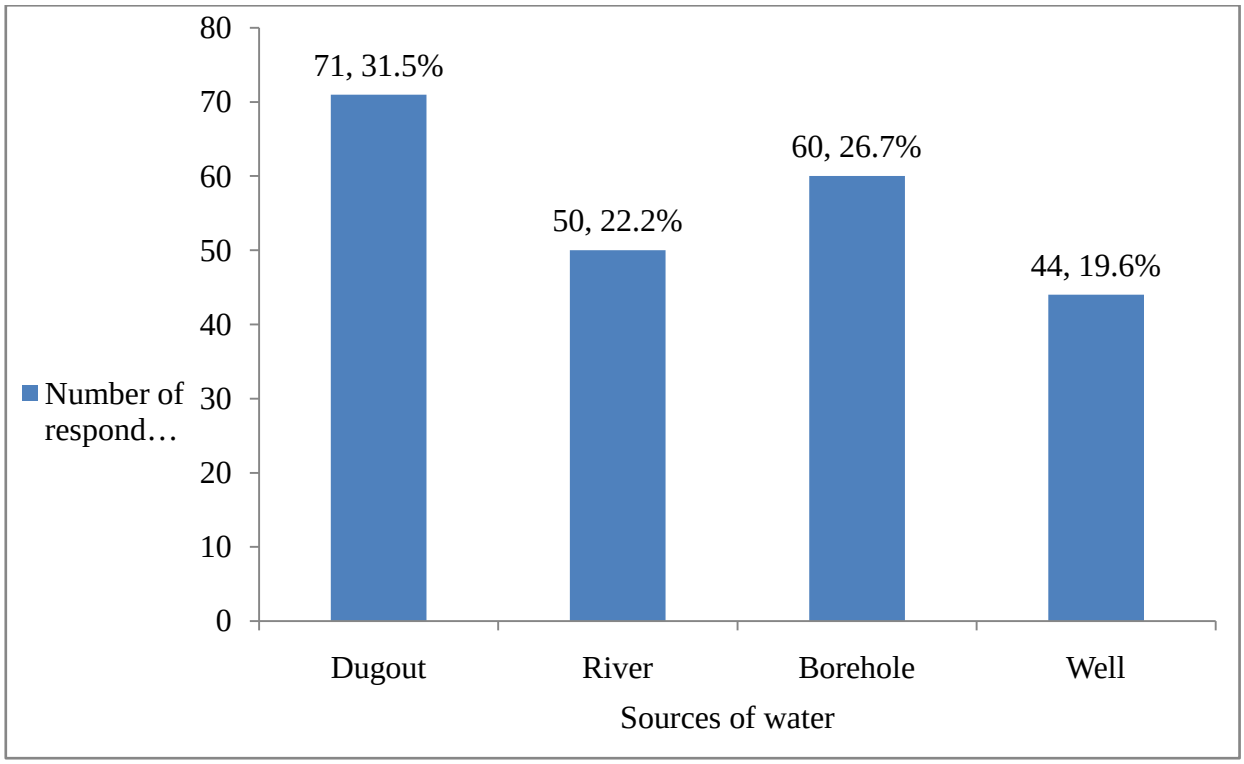

Figure 7: Source of Water for Households. Source; Field survey, 2020

The study showed that, the sources of water in the district are not safe. According to Pickut (2015), clean water is water that is safe enough to drink by humans because it is protected at source and free of mineral and biological pollutants, and so cannot cause harm. However, majority of the respondents depends on river water and boreholes which could be contaminated with pathogenic bacterial and heavy metals due to human activities and mineralization of underlying rocks. Water is a limited resource all over the world and increasing amounts of organic waste threaten water resources quality and availability. Research in the Densu River basin by Karikari and Ansa-Asare (2006), concluded in their study that microbial presence in the river was due to contamination caused by human activities such as intensive agriculture and livestock. Groundwater resource is generally good except for some cases of localized pollution and areas with high levels of iron, fluoride and other minerals (USAID, 2011). This is worsened by climate change; a phenomenon caused by increasing emissions of Carbon dioxide and other greenhouse gases (Nitrous Oxide, Nitric acid, Methane, Chlorofluorocarbons, etc) and subsequently increasing temperatures in the atmosphere (Asumadu-Sarkodie & Owusu, 2016). The impact of climate change in Mion District is felt on water resources with research showing that there is increased evaporation, decreased and highly variable rainfall pattern, and frequent pronounced flood and drought situations (Asumadu-Sarkodie et al., 2015a; Asumadu-Sarkodie et al., 2015b). The impacts of the rising temperature are felt in the dry season (December–March) (Asumadu-Sarkodie et al., 2015b). In Mion District, the felling of trees for firewood, charcoal production farming and development contribute to deforestation.

j) Relationship between socio-demographic characteristics and indicators of open defecation free communities

The research sought to find out whether there was a relationship between household sizes and the communities within the study area. The column percentages show that there was a remarkable difference in the communities in terms of household sizes. Household size between1-5 was likely to be found at Montolo with 26.9% as compared to other communities (Appendix I). A household size of 6-10 and 11-15 were likely to be found at Jibilago with 23.2% and 24.3% respectively. The finding of household size of 11-15 at Jibilago was similar to Bungbali which all had 24.5%. A household size of 16-20 was likely to be found at Nkwanta with 40.0%. In addition, a household size of 21-25 was more likely to be found at Wasambo with 22.6%. Furthermore a household size of over 26 persons was likely to be found at Binagmando with 66.7%. The differences in the percentages show that there was a relationship between the household size and he communities. A Pearson Chi-square of p=0.00 (Table 3) indicated that there was a strong relationship between household size and the communities.

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Table 3: Pearson Chi-square between household size and open defecation free communities

	Value	d	Asymp. Sig. (2-sided)
Pearson Chi-Square	224.610[a]	65	.000
Likelihood Ratio	230.239	65	.000
Linear-by-Linear Association	.466	1	.495
N of Valid Cases	225		

a. 72 cells (85.7%) have expected count less than 5. The minimum expected count is .07.

The findings agreed with Osumanu et al., (2016) that household size was a determinant of open defecation in the Wa Municipality of the Upper West Region of Ghana. This is because when the household size is large, not all household members will have the patience to wait especially during the early hours of the day when they have to free themselves and get to work. Again large household size put pressure on the household toilets leading to a reduction in their life span. Next, the study investigated the relationship between the ages of respondents and the communities of residents. Respondents who were less than 26-years were most likely to be found in Wasambo with 26.5% while those between 26 and 30 were found at Binagmando with 29.7% (Appendix II). Respondents who were between 31- 35 years and 36-40 years were mostly found at Namoni with 38.5% and 42.9% respectively. The ages of those with 41-45 years were mostly found at Nayinku with 38.9% and those within 46-50 years were mostly found at Bungbali with 37.5%. Respondents aged between51-55 years were largely found at Kubbagmado with 29.4%. Respondents aged between 55 and 60-yeas were mostly found at Nayinku with21.4% and those above 60 were largely found at Motondo with 25.0%. The variation in the percentages shows that there was a relationship between the ages of respondents and the communities they reside. The Chi-square analysis suggest that there was a strong relationship between the ages of respondents and the communities they reside at a Pearson Chi-square of p=0.00 (Table 4).

Table 4: Pearson Chi-square between ages of respondents and open defecation free indicators in communities

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	385.739[a]	104	.000
Likelihood Ratio	372.038	104	.000
Linear-by-Linear Association	.040	1	.841
N of Valid Cases	225		

a. 125 cells (99.2%) have expected count less than 5. The minimum expected count is .31.

The findings indicate that age was a determinant of open defecation in the Mion District. This is because household heads that are old are not financially sound to construct household toilets.

Furthermore, the study investigated the relationship between sex and the communities of residents. The percentages for male and female were the highest at Motondo with 14.7% and 14.5% respectively (Appendix III). However, a Pearson Chi-square of p>0.00 (Table 5) shows that, there was no relationship between sex and open defecation free communities.

Table 5: Pearson Chi-square between sex of respondents and open defecation free indicators in communities

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	3.352[a]	13	.996
Likelihood Ratio	3.455	13	.996
Linear-by-Linear Associatior	.212	1	.645
N of Valid Cases	225		

a. 13 cells (46.4%) have expected count less than 5. The minimum expected count is 1.22.

The findings suggest that open defecation is not gender base. Both male and female engage in open defecation.

In addition, the study investigated the relationship between religion and open defecation free communitie. Majority of the respondents were Muslims (30.0%) at Jibilago and majority of Christians (23.1%) at Motondo. (Appendix IV) The percentage of Traditional believers at Jibilago was similar to those at Motondo with12.8%. The differences in percentage of the religious beliefs of the residents in the communities show that there was a relationship between religion and the study communities. The study demonstrated that there was a relationship between religion and the communities of residents with a Pearson Chi-square of p=0.0 (Table 6).

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Table 6: Pearson Chi-square between religion of respondents and open defecation free indicators in communities

	Value	Asymp. Sig. (2-sided)
Pearson Chi-Square	77.687[a]	.000
Likelihood Ratio	87.663	.000
Linear-by-Linear Association	12.106	.001
N of Valid Cases	225	

a. 21 cells (50.0%) have expected count less than 5. The minimum expected count is .89.

The study suggests that open defecation and religion are highly related. This finding agreed with Osumanu et al., (2016) that religion and belief systems determine open defecation. For example, among Moslems male and female do not share a common toilet. This means every household must have a minimum of two toilets in a Muslim community.

The study showed that 94.5% of the respondents were engaged in farming. Other sectors of the economy of Mion District were the service and the sales sector. There was no relationship between the occupation of respondents and their community of residents as far as sanitation was concerned (Appendix V). The Pearson Chi-sqaure results indicated a probability $p>0.05$ (Table 7) and so the null hypothesis that there was no relationship between the occupation of respondents and the community they reside was accepted. The result suggested that sanitation related activity is not based on one's occupation.

Table 7: Pearson Chi-square between occupation of respondents and open defecation free communities

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	17.597[a]	26	.890
Likelihood Ratio	14.165	26	.971
Linear-by-Linear Association	1.475	1	.225
N of Valid Cases	225		

a. 29 cells (69.0%) have expected count less than 5. The minimum expected count is .04.

Open defecation is not a determinant on the type or form of livelihood or occupation. However, Osumanu et al., (2016) have observed thatthose who are employed are able to mobilize money to construct household toilets.Osumanu and Kosoe (2013) argued that financial constraints present inhibits house owners from the provision of household toilets, and fees charged by public toilet operators.

Furthermore the study looked at the presence of water for washing hands at the household toilets. Most people (13.8%) at Motondo and Jibilago had water for washing their hands. Also 16.2% of the residents of Motondo had no water for hand washing at their toilets. The differences in percentages show that there was a relationship between water presence at household toilets and the communities (Appendix IX). The Pearson Chi-square shows a $p<0.05$ (Table 11) and indicate a relationship.

Table 11: Pearson Chi-square between water presence at latrines and open defecation free communities

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	26.010[a]	13	.017
Likelihood Ratio	28.723	13	.007
Linear-by-Linear Association	.393	1	.531
N of Valid Cases	225		

a. 7 cells (25.0%) have expected count less than 5. The minimum expected count is 1.78.

The result is in sync with Osuman et al., (2016) that toilet ownership and the presence of water at the toilets were a determinant of open defecation. Toilets which have water provide opportunity for users to wash their hands after defecation. Water presence at toilet facilities is therefore a motivation for people to use the toilets.

In addition Jibilago and Motondo both had the highest percentage (12.3%) of toilets with soap and Motondo had most (19.7%) of household toilets without soap. The cross tabulation showed there was a relationship (Appendix X). However, The Pearson Chi-square indicates $p=0.052$ (Table 12) and hence there was no relationship between household toilets with soap and the communities of residents.

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Table 12: Pearson Chi-square between toilets with soap and open defecation free communities

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	22.225[a]	13	.052
Likelihood Ratio	21.579	13	.062
Linear-by-Linear Association	1.862	1	.172
N of Valid Cases	225		

a. 9 cells (32.1%) have expected count less than 5. The minimum expected count is 1.58.

The presence of soap according to the study did not matter so much to the users of toilets. As long as there was water to wash their hands after defecation they were content with that. As a result of nonuse of soap after using the toilet, 200,000 children under the age of five die from diarrhoea annually in Sub-Saharan Africa, while the numbers dying from cholera within the region are similarly high because of poor sanitation, hygiene practices, and unsafe water supplies (WHO, 2014).

The sources of water in the communities were stream, boreholes and dugouts. It was indicated that most people (18.4%) of households in Motondo depends on stream water, 17.9% of households in Jibilago depends on boreholes and the percentage of those who depends on dugouts at Jibilago and Motondo were similar (12.7%) (Appendiix XI). This show that while most people in Jibilago depends on boreholes and dugouts most households in Motondo depended on stream and dugouts for water. The Pearson Chi-square $p>0.05$ (Table 13) showed that that there was no relationship between sources of water and the communities of residents.

Table 13: Pearson Chi-square between sources of water soap and open defecation free communities

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	20.787[a]	26	.753
Likelihood Ratio	21.617	26	.709
Linear-by-Linear Association	4.010	1	.045
N of Valid Cases	225		

a. 21 cells (50.0%) have expected count less than 5. The minimum expected count is 1.49.

The source of water was not a determinant of open defecation and so there was no relation. Any water could be used to wash hands after defecation.

k) Sustaining CLTS in the Mion District

According to Water Aid(2008) identified negative attitudes involving carelessness, disrespect for traditional authority, and community norms as determinants of open defecation. It is therefore important that bylaws and enforcements are put in place in all communities to check open defecation. Also, Jenkins and Scott [11], identified behavioural patterns such as preference, intention, and choice as the determinants of open defecation in poor communities. Continuous education and sensitization are important to ensure that communities that have attained open defecation free status do not relapse into open defecation status.

Building local capacity and engaging local leaders has been reported as an enabling factor for other WaSH behaviors, such as sustainability of household-water treatment and storage (HWTS) practices (Ojomo et al., 2015). The local leaders and the youth are trained by the district environmental health officers. Trained local actors influence the behavior of their peers with diffusion theory, in which, among other factors, peer-communication and opinion leaders influence the adoption of a new behavior (Rogers, 2003).

Water management in Ghana is regulated by the Water Resources Commission (WRC). The WRC of Ghana was established by an Act of Parliament (Act 522 of 1996) to regulate and mange Ghana's water resources and co-ordinate government policies in relation to them. Act 522 of 1996 has vested ownership and control of all water sources in the President on behalf of the people (WRC Ghana, 2015). Ensuring adequate quality supply of water availability for human use is essential(Oki & Kanae, 2006). Water management is divided into three classifications: managing the resource, managing water services, and ensuring a balance between supply and demand (United Nations, 2015).

Rainwater harvesting is common in the Mion District and has a great potential to increase water availability in certain localized areas (WRC Ghana, 2015). According to Anokye and Gupta (2012), Integrated Water Resources Management (IWRM) is an integrated approach that ensures public participation, the role of gender and recognizing the economic value of water. IWRM also advocate awareness creation of the importance of water among policy-makers and the public (Lonergan & Brooks, 1994) and involves users of water in the planning and implementation of water projects. IWRM ensures that, the management, operation and maintenance of water resources are placed in the hands of community members (Anokye & Gupta, 2012; WRC Ghana, 2015).

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IV. Conclusions and Recommendations

Achieving total sanitation (100.0% open defecation free) status in the Mion District will be a mirage since the aged cannot construct household toilets and household toilets that were constructed since 2017 are collapsing and needs replacement. The cost of constructing new toilets is rising and not all can afford to own household toilet. Some households who are willing to own toilets complained of poverty and lack of technical support. Soap for washing their hands after defecation is almost absent because they do not see the importance of washing hands with soap. A larger household size that depends on only one toilet is likely to practice open defecation because there are no public toilets. The aged, children and the sick are most likely to practice open defecation if there are no household toilets and they cannot visit their neighbors' homes because they are weak and cannot walk. Religion and the belief systems are keyto open defecation because the mallams and the pastors take part in advocacies and education on sanitation and open defecation. The district depends on surface and ground water sources which are not treated and often dry up during the dry season. However, the source of water for the washing of hands and maintaining good sanitation was important in sanitation and hygiene management. The study recommends that, materials needed for toilet construction be subsidized even though this will defeat the purpose of CLTS. Above all, the sick, the aged and the poor must be supported by community members, the government and benevolent organizations to enable them own household toilets. Continuous education and sensitization on sustaining open defecation free (ODF) status. Collaboration between governmental, nongovernmental agencies and traditional leaders is important to achieve total sanitation in the Mion District.

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Appendices

Appendix I: Relationship between household size and open defecation free communities

			Household size						Total
			1-5	6-10	11-15	16-20	21-25	26 and above	
Community	Jilma	Count	6_a	$5_{a,b}$	0_b	$0_{a,b}$	0_b	$0_{a,b}$	11
		% within HHsize	11.5%	6.1%	0.0%	0.0%	0.0%	0.0%	4.9%
	Jibilago	Count	0_a	19_b	9_b	$1_{a,b}$	0_a	$0_{a,b}$	29
		% within HHsize	0.0%	**23.2%**	**24.3%**	5.0%	0.0%	0.0%	12.9%
	Nkwanta	Count	0_a	7_b	$0_{a,b}$	8_c	$0_{a,b}$	$0_{a,b,c}$	15
		% within HHsize	0.0%	8.5%	0.0%	**40.0%**	0.0%	0.0%	6.7%
	Kpumale	Count	8_a	2_b	0_b	$1_{a,b}$	0_b	$0_{a,b}$	11
		% within HHsize	15.4%	2.4%	0.0%	5.0%	0.0%	0.0%	4.9%
	Wasambo	Count	0_a	8_b	0_a	3_b	7_b	$0_{a,b}$	18
		% within HHsize	0.0%	9.8%	0.0%	15.0%	**22.6%**	0.0%	8.0%
	Macheliyili	Count	4_a	1_a	0_a	0_a	0_a	0_a	5
		% within HHsize	7.7%	1.2%	0.0%	0.0%	0.0%	0.0%	2.2%
	Kubbagmado	Count	5_a	5_a	2_a	0_a	4_a	0_a	16
		% within HHsize	9.6%	6.1%	5.4%	0.0%	12.9%	0.0%	7.1%
	Frigmagdo	Count	$3_{a,b}$	$6_{a,b}$	$2_{a,b}$	0_b	6_a	$0_{a,b}$	17
		% within HHsize	5.8%	7.3%	5.4%	0.0%	19.4%	0.0%	7.6%
	Tuya	Count	0_a	$4_{a,b}$	$0_{a,b}$	$0_{a,b}$	3_b	$0_{a,b}$	7
		% within HHsize	0.0%	4.9%	0.0%	0.0%	9.7%	0.0%	3.1%
	Namoni	Count	0_a	$12_{b,c}$	$1_{a,c}$	$0_{a,c}$	6_b	1_b	20
		% within HHsize	0.0%	14.6%	2.7%	0.0%	19.4%	33.3%	8.9%
	Binagmando	Count	4_a	4_a	3_a	0_a	2_a	2_b	15
		% within HHsize	7.7%	4.9%	8.1%	0.0%	6.5%	**66.7%**	6.7%
	Motondo	Count	14_a	4_b	$6_{a,c}$	7_a	$2_{b,c}$	$0_{a,b,c}$	33
		% within HHsize	**26.9%**	4.9%	16.2%	35.0%	6.5%	0.0%	14.7%
	Nanyinku	Count	6_a	0_b	5_a	$0_{a,b}$	$1_{a,b}$	$0_{a,b}$	12
		% within HHsize	11.5%	0.0%	13.5%	0.0%	3.2%	0.0%	5.3%
	Bungbali	Count	2_a	5_a	9_b	0_a	0_a	$0_{a,b}$	16
		% within HHsize	3.8%	6.1%	**24.3%**	0.0%	0.0%	0.0%	7.1%
Total		Count	52	82	37	20	31	3	225
		% within HHsize	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Each subscript letter denotes a subset of HHsize categories whose column proportions do not differ significantly from each other at the .05 level.

Appendix II: Relationship between age groups and open defecation free communities

			Age group								Total
			Less 26	26-30	31-35	36-40	41-45	46-50	51-55	56-60 61 and above	
Com-munity	Jilma	Count	5_a	$2_{a,b,c}$	$3_{a,c}$	$0_{a,b,c}$	$0_{a,b,c}$	$0_{b,c}$	$0_{a,b,c}$	$1_{a,b,c}$ 0_b	11
		% within AgeGp	14.7%	5.4%	11.5%	0.0%	0.0%	0.0%	0.0%	4.3% 0.0%	4.9%
	Jibilago	Count	$4_{a,b}$	$5_{a,b}$	0_b	3_a	3_a	4_a	3_a	$3_{a,b}$ $4_{a,b}$	29
		% within AgeGp	11.8%	13.5%	0.0%	21.4%	16.7%	16.7%	17.6%	13.0% 12.5%	12.9%
	Nkwanta	Count	0_a	$2_{a,b,c}$	$2_{a,b,c}$	3_c	3_c	$3_{b,c}$	$2_{b,c}$	$0_{a,b}$ 0_a	15
		% within AgeGp	0.0%	5.4%	7.7%	21.4%	16.7%	12.5%	11.8%	0.0% 0.0%	6.7%
	Kpumale	Count	$3_{a,b}$	0_b	0_b	$0_{a,b}$	$0_{a,b}$	0_b	$1_{a,b}$	$2_{a,b}$ 5_a	11
		% within AgeGp	8.8%	0.0%	0.0%	0.0%	0.0%	0.0%	5.9%	8.7% 15.6%	4.9%

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Wasambo	Count	9_{a}	$3_{b, c}$	0_{c}	$0_{b, c}$	$0_{b, c}$	0_{c}	$0_{b, c}$	0_{c}	$6_{a, b}$	18
	% within AgeGp	**26.5%**	8.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	18.8%	8.0%
Macheliyili	Count	0_{a}	4_{b}	$1_{a, b}$	$0_{a, b}$	$0_{a, b}$	$0_{a, b}$	$0_{a, b}$	$0_{a, b}$	$0_{a, b}$	5
	% within AgeGp	0.0%	10.8%	3.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.2%
Kubbagmado	Count	0_{a}	0_{a}	$2_{a, b, c, d, e, f}$	$0_{a, e, f}$	$0_{a, d, f}$	$4_{b, c, d, e, f}$	5_{c}	$4_{b, c, d, e, f}$	$1_{a, b, d, e, f}$	16
	% within AgeGp	0.0%	0.0%	7.7%	0.0%	0.0%	16.7%	**29.4%**	17.4%	3.1%	7.1%
Frigmagdo	Count	$3_{a, b, c, d, e}$	$0_{d, e}$	$0_{c, e}$	$0_{a, b, c, d, e}$	3_{b}	4_{b}	3_{b}	4_{b}	$0_{a, c, d, e}$	17
	% within AgeGp	8.8%	0.0%	0.0%	0.0%	16.7%	16.7%	17.6%	17.4%	0.0%	7.6%
Tuya	Count	0_{a}	0_{a}	$0_{a, b}$	$0_{a, b, c}$	$0_{a, b, c}$	$0_{a, b}$	3_{c}	$0_{a, b}$	$4_{b, c}$	7
	% within AgeGp	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	17.6%	0.0%	12.5%	3.1%
Namoni	Count	0_{a}	0_{a}	10_{b}	6_{b}	$0_{a, c}$	$0_{a, c}$	$0_{a, c}$	$0_{a, c}$	4_{c}	20
	% within AgeGp	0.0%	0.0%	**38.5%**	**42.9%**	0.0%	0.0%	0.0%	0.0%	12.5%	8.9%
Binagmandoo	Count	0_{a}	11_{b}	$4_{b, c}$	$0_{a, c}$	$0_{a, c}$	0_{a}	$0_{a, c}$	0_{a}	0_{a}	15
	% within AgeGp	0.0%	**29.7%**	15.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	6.7%
Motondo	Count	$5_{a, b, c}$	10_{c}	$4_{a, b, c}$	$2_{a, b, c, d}$	$0_{b, d}$	0_{d}	$0_{b, d}$	$4_{a, b, c}$	$8_{a, c}$	33
	% within AgeGp	14.7%	27.0%	15.4%	14.3%	0.0%	0.0%	0.0%	17.4%	**25.0%**	14.7%
Nanyinku	Count	0_{a}	0_{a}	0_{a}	$0_{a, b}$	7_{c}	0_{a}	0_{a}	$5_{b, c}$	0_{a}	12
	% within AgeGp	0.0%	0.0%	0.0%	0.0%	**38.9%**	0.0%	0.0%	**21.7%**	0.0%	5.3%
Bungbali	Count	5_{a}	0_{b}	$0_{b, c}$	$0_{a, b, c}$	$2_{a, c, d}$	9_{d}	$0_{a, b, c}$	$0_{a, b, c}$	$0_{b, c}$	16
	% within AgeGp	14.7%	0.0%	0.0%	0.0%	11.1%	**37.5%**	0.0%	0.0%	0.0%	7.1%
Total	Count	34	37	26	14	18	24	17	23	32	225
	% within AgeGp	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Each subscript letter denotes a subset of AgeGp categories whose column proportions do not differ significantly from each other at the .05 level.

Appendix III: Relationship between sex of respondents and open defecation free communities

			Sex of respondents		Total
			Male	Female	
Community	Jilma	Count	7_{a}	4_{a}	11
		% within Sex	4.1%	7.3%	4.9%
	Jibilago	Count	23_{a}	6_{a}	29
		% within Sex	13.5%	10.9%	12.9%
	Nkwanta	Count	12_{a}	3_{a}	15
		% within Sex	7.1%	5.5%	6.7%
	Kpumale	Count	8_{a}	3_{a}	11
		% within Sex	4.7%	5.5%	4.9%
	Wasambo	Count	14_{a}	4_{a}	18
		% within Sex	8.2%	7.3%	8.0%
	Macheliyili	Count	4_{a}	1_{a}	5
		% within Sex	2.4%	1.8%	2.2%
	Kubbagmado	Count	14_{a}	2_{a}	16
		% within Sex	8.2%	3.6%	7.1%
	Frigmagdo	Count	12_{a}	5_{a}	17
		% within Sex	7.1%	9.1%	7.6%
	Tuya	Count	5_{a}	2_{a}	7
		% within Sex	2.9%	3.6%	3.1%
	Namoni	Count	15_{a}	5_{a}	20
		% within Sex	8.8%	9.1%	8.9%

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	Binagmando	Count	11_a	4_a	15
		% within Sex	6.5%	7.3%	6.7%
	Motondo	Count	25_a	8_a	33
		% within Sex	**14.7%**	**14.5%**	14.7%
	Nanyinku	Count	9_a	3_a	12
		% within Sex	5.3%	5.5%	5.3%
	Bungbali	Count	11_a	5_a	16
		% within Sex	6.5%	9.1%	7.1%
Total		Count	170	55	225
		% within Sex	100.0%	100.0%	100.0%

Each subscript letter denotes a subset of Sex categories whose column proportions do not differ significantly from each other at the .05 level.

Appendix IV: Relationship between religion of respondents and open defecation free communities

			Religion			Total
			Muslim	Christi	African Traditional Religion	
Community	Jilma	Count	5_a	1_b	$5_{a,b}$	11
		% within Religion	12.5%	1.1%	5.3%	4.9%
	Jibilago	Count	12_a	5_b	12_b	29
		% within Religion	**30.0%**	5.5%	**12.8%**	12.9%
	Nkwanta	Count	8_a	3_b	4_b	15
		% within Religion	20.0%	3.3%	4.3%	6.7%
	Kpumale	Count	3_a	3_a	5_a	11
		% within Religion	7.5%	3.3%	5.3%	4.9%
	Wasambo	Count	6_a	2_b	10_a	18
		% within Religion	15.0%	2.2%	10.6%	8.0%
	Macheliyili	Count	2_a	1_a	2_a	5
		% within Religion	5.0%	1.1%	2.1%	2.2%
	Kubbagmado	Count	2_a	8_a	6_a	16
		% within Religion	5.0%	8.8%	6.4%	7.1%
	Frigmagdo	Count	1_a	6_a	10_a	17
		% within Religion	2.5%	6.6%	10.6%	7.6%
	Tuya	Count	0_a	4_a	3_a	7
		% within Religion	0.0%	4.4%	3.2%	3.1%
	Namoni	Count	1_a	14_b	5_a	20
		% within Religion	2.5%	15.4%	5.3%	8.9%
	Binagmando	Count	0_a	8_a	7_a	15
		% within Religion	0.0%	8.8%	7.4%	6.7%
	Motondo	Count	0_a	21_b	12_b	33
		% within Religion	0.0%	**23.1%**	**12.8%**	14.7%
	Nanyinku	Count	0_a	5_a	7_a	12
		% within Religion	0.0%	5.5%	7.4%	5.3%
	Bungbali	Count	0_a	10_b	$6_{a,b}$	16
		% within Religion	0.0%	11.0%	6.4%	7.1%
Total		Count	40	91	94	225
		% within Religion	100.0%	100.0%	100.0%	100.0%

Each subscript letter denotes a subset of Religion categories whose column proportions do not differ significantly from each other at the .05 level.

Appendix V: Relationship between occupation of respondents and open defecation free communities

			Occupation			Total
			Farming	Trading	Government	
Community	Jilma	Count	10_a	1_a	0_a	11
		% within Occupation	4.7%	10.0%	0.0%	4.9%
	Jibilago	Count	28_a	1_a	0_a	29
		% within Occupation	13.1%	10.0%	0.0%	12.9%
	Nkwanta	Count	15_a	0_a	0_a	15

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	% within Occupation	7.0%	0.0%	0.0%	6.7%
Kpumale	Count	10_a	1_a	0_a	11
	% within Occupation	4.7%	10.0%	0.0%	4.9%
Wasambo	Count	18_a	0_a	0_a	18
	% within Occupation	8.5%	0.0%	0.0%	8.0%
Macheliyili	Count	5_a	0_a	0_a	5
	% within Occupation	2.3%	0.0%	0.0%	2.2%
Kubbagmado	Count	15_a	1_a	0_a	16
	% within Occupation	7.0%	10.0%	0.0%	7.1%
Frigmagdo	Count	16_a	1_a	0_a	17
	% within Occupation	7.5%	10.0%	0.0%	7.6%
Tuya	Count	7_a	0_a	0_a	7
	% within Occupation	3.3%	0.0%	0.0%	3.1%
Namoni	Count	18_a	$1_{a, b}$	1_b	20
	% within Occupation	8.5%	10.0%	50.0%	8.9%
Binagmando	Count	14_a	1_a	0_a	15
	% within Occupation	6.6%	10.0%	0.0%	6.7%
Motondo	Count	32_a	1_a	0_a	33
	% within Occupation	15.0%	10.0%	0.0%	14.7%
Nanyinku	Count	10_a	$1_{a, b}$	1_b	12
	% within Occupation	4.7%	10.0%	50.0%	5.3%
Bungbali	Count	15_a	1_a	0_a	16
	% within Occupation	7.0%	10.0%	0.0%	7.1%
Total	Count	213	10	2	225
	% within Occupation	100.0%	100.0%	100.0%	100.0%

Each subscript letter denotes a subset of Occupation categories whose column proportions do not differ significantly from each other at the .05 level.

Appendix VI: Relationship between the management of bath water of respondents and open defecation free communities

			Management of bath water		Total
			Yes	No	
Community	Jilma	Count	4_a	7_a	11
		% within MgtBathwater	6.9%	4.2%	4.9%
	Jibilago	Count	9_a	20_a	29
		% within MgtBathwater	15.5%	12.0%	12.9%
	Nkwanta	Count	5_a	10_a	15
		% within MgtBathwater	8.6%	6.0%	6.7%
	Kpumale	Count	2_a	9_a	11
		% within MgtBathwater	3.4%	5.4%	4.9%
	Wasambo	Count	4_a	14_a	18
		% within MgtBathwater	6.9%	8.4%	8.0%
	Macheliyili	Count	1_a	4_a	5
		% within MgtBathwater	1.7%	2.4%	2.2%
	Kubbagmado	Count	5_a	11_a	16
		% within MgtBathwater	8.6%	6.6%	7.1%
	Frigmagdo	Count	4_a	13_a	17
		% within MgtBathwater	6.9%	7.8%	7.6%
	Tuya	Count	1_a	6_a	7
		% within MgtBathwater	1.7%	3.6%	3.1%
	Namoni	Count	6_a	14_a	20
		% within MgtBathwater	10.3%	8.4%	8.9%
	Binagmando	Count	3_a	12_a	15
		% within MgtBathwater	5.2%	7.2%	6.7%
	Motondo	Count	7_a	26_a	33
		% within MgtBathwater	12.1%	15.6%	14.7%
	Nanyinku	Count	3_a	9_a	12
		% within MgtBathwater	5.2%	5.4%	5.3%
		Count	4_a	12_a	16

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Bungbali	% within MgtBathwater	6.9%	7.2%	7.1%
Total	Count	58	167	225
	% within MgtBathwater	100.0%	100.0%	100.0%

Each subscript letter denotes a subset of Mgt Bathwater categories whose column proportions do not differ significantly from each other at the .05 level.

Appendix VII: Relationship between Solid waste management and open defecation free communities

			Solid waste management		Total
			Bury	Burn	
Community	Jilma	Count	7_a	4_a	11
		% within solidwastemgt	3.9%	8.5%	4.9%
	Jibilago	Count	23_a	6_a	29
		% within solidwastemgt	12.9%	12.8%	12.9%
	Nkwanta	Count	13_a	2_a	15
		% within solidwastemgt	7.3%	4.3%	6.7%
	Kpumale	Count	8_a	3_a	11
		% within solidwastemgt	4.5%	6.4%	4.9%
	Wasambo	Count	15_a	3_a	18
		% within solidwastemgt	8.4%	6.4%	8.0%
	Macheliyili	Count	5_a	0_a	5
		% within solidwastemgt	2.8%	0.0%	2.2%
	Kubbagmado	Count	11_a	5_a	16
		% within solidwastemgt	6.2%	10.6%	7.1%
	Frigmagdo	Count	14_a	3_a	17
		% within solidwastemgt	7.9%	6.4%	7.6%
	Tuya	Count	5_a	2_a	7
		% within solidwastemgt	2.8%	4.3%	3.1%
	Namoni	Count	16_a	4_a	20
		% within solidwastemgt	9.0%	8.5%	8.9%
	Binagmando	Count	12_a	3_a	15
		% within solidwastemgt	6.7%	6.4%	6.7%
	Motondo	Count	27_a	6_a	33
		% within solidwastemgt	15.2%	12.8%	14.7%
	Nanyinku	Count	10_a	2_a	12
		% within solidwastemgt	5.6%	4.3%	5.3%
	Bungbali	Count	12_a	4_a	16
		% within solidwastemgt	6.7%	8.5%	7.1%
Total		Count	178	47	225
		% within solidwastemgt	100.0%	100.0%	100.0%

Each subscript letter denotes a subset of solid waste mgt categories whose column proportions do not differ significantly from each other at the .05 level.

Appendix VIII: Relationship between latrine cover and open defecation free communities

			Latrine cover		Total
			Yes	No	
Community	Jilma	Count	8_a	3_a	11
		% within LatrineCover	5.1%	4.4%	4.9%
	Jibilago	Count	24_a	5_a	29
		% within LatrineCover	15.3%	7.4%	12.9%
	Nkwanta	Count	12_a	3_a	15
		% within LatrineCover	7.6%	4.4%	6.7%
	Kpumale	Count	7_a	4_a	11
		% within LatrineCover	4.5%	5.9%	4.9%
	Wasambo	Count	14_a	4_a	18
		% within LatrineCover	8.9%	5.9%	8.0%
	Macheliyili	Count	4_a	1_a	5
		% within LatrineCover	2.5%	1.5%	2.2%

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Kubbagmado	Count	7_a	9_b	16
	% within LatrineCover	4.5%	13.2%	7.1%
Frigmagdo	Count	11_a	6_a	17
	% within LatrineCover	7.0%	8.8%	7.6%
Tuya	Count	5_a	2_a	7
	% within LatrineCover	3.2%	2.9%	3.1%
Namoni	Count	15_a	5_a	20
	% within LatrineCover	9.6%	7.4%	8.9%
Binagmando	Count	9_a	6_a	15
	% within LatrineCover	5.7%	8.8%	6.7%
Motondo	Count	20_a	13_a	33
	% within LatrineCover	12.7%	19.1%	14.7%
Nanyinku	Count	9_a	3_a	12
	% within LatrineCover	5.7%	4.4%	5.3%
Bungbali	Count	12_a	4_a	16
	% within LatrineCover	7.6%	5.9%	7.1%
Total	Count	157	68	225
	% within LatrineCover	100.0%	100.0%	100.0%

Each subscript letter denotes a subset of Latrine Cover categories whose column proportions do not differ significantly from each other at the .05 level.

Appendix IX: Relationship between water presence at toilets and open defecation free communities

			Water presence at toilet		Total
			Yes	No	
Community	Jilma	Count	8_a	3_a	11
		% within WaterPresence	5.5%	3.8%	4.9%
	Jibilago	Count	20_a	9_a	29
		% within WaterPresence	13.8%	11.2%	12.9%
	Nkwanta	Count	10_a	5_a	15
		% within WaterPresence	6.9%	6.2%	6.7%
	Kpumale	Count	10_a	1_a	11
		% within WaterPresence	6.9%	1.2%	4.9%
	Wasambo	Count	8_a	10_a	18
		% within WaterPresence	5.5%	12.5%	8.0%
	Macheliyili	Count	4_a	1_a	5
		% within WaterPresence	2.8%	1.2%	2.2%
	Kubbagmado	Count	10_a	6_a	16
		% within WaterPresence	6.9%	7.5%	7.1%
	Frigmagdo	Count	14_a	3_a	17
		% within WaterPresence	9.7%	3.8%	7.6%
	Tuya	Count	0_a	7_b	7
		% within WaterPresence	0.0%	8.8%	3.1%
	Namoni	Count	14_a	6_a	20
		% within WaterPresence	9.7%	7.5%	8.9%
	Binagmando	Count	7_a	8_a	15
		% within WaterPresence	4.8%	10.0%	6.7%
	Motondo	Count	20_a	13_a	33
		% within WaterPresence	13.8%	16.2%	14.7%
	Nanyinku	Count	9_a	3_a	12
		% within WaterPresence	6.2%	3.8%	5.3%
	Bungbali	Count	11_a	5_a	16
		% within WaterPresence	7.6%	6.2%	7.1%
Total		Count	145	80	225
		% within WaterPresence	100.0%	100.0%	100.0%

Each subscript letter denotes a subset of Water Presence categories whose column proportions do not differ significantly from each other at the .05 level.

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Appendix X: Relationship between the presence of soap at toilets and open defecation free communities

			Soap presence at toilet		Total
			Yes	No	
Community	Jilma	Count	8_a	3_a	11
		% within SoapPresence	5.2%	4.2%	4.9%
	Jibilago	Count	19_a	10_a	29
		% within SoapPresence	**12.3%**	14.1%	12.9%
	Nkwanta	Count	10_a	5_a	15
		% within SoapPresence	6.5%	7.0%	6.7%
	Kpumale	Count	8_a	3_a	11
		% within SoapPresence	5.2%	4.2%	4.9%
	Wasambo	Count	5_a	13_b	18
		% within SoapPresence	3.2%	18.3%	8.0%
	Macheliyili	Count	4_a	1_a	5
		% within SoapPresence	2.6%	1.4%	2.2%
	Kubbagmado	Count	12_a	4_a	16
		% within SoapPresence	7.8%	5.6%	7.1%
	Frigmagdo	Count	13_a	4_a	17
		% within SoapPresence	8.4%	5.6%	7.6%
	Tuya	Count	5_a	2_a	7
		% within SoapPresence	3.2%	2.8%	3.1%
	Namoni	Count	17_a	3_a	20
		% within SoapPresence	11.0%	4.2%	8.9%
	Binagmando	Count	11_a	4_a	15
		% within SoapPresence	7.1%	5.6%	6.7%
	Motondo	Count	19_a	14_a	33
		% within SoapPresence	**12.3%**	**19.7%**	14.7%
	Nanyinku	Count	10_a	2_a	12
		% within SoapPresence	6.5%	2.8%	5.3%
	Bungbali	Count	13_a	3_a	16
		% within SoapPresence	8.4%	4.2%	7.1%
Total		Count	154	71	225
		% within SoapPresence	100.0%	100.0%	100.0%

Each subscript letter denotes a subset of SoapPresence categories whose column proportions do not differ significantly from each other at the .05 level.

Appendix XI: Relationship between water source of respondents and open defecation free communities

			Water source for community members			Total
			Stream	Bore hole	Dugout	
Community	Jilma	Count	1_a	6_b	$4_{a,b}$	11
		% within WaterSource	1.1%	9.0%	5.6%	4.9%
	Jibilago	Count	8_a	12_a	9_a	29
		% within WaterSource	9.2%	**17.9%**	**12.7%**	12.9%
	Nkwanta	Count	6_a	4_a	5_a	15
		% within WaterSource	6.9%	6.0%	7.0%	6.7%
	Kpumale	Count	2_a	3_a	6_a	11
		% within WaterSource	2.3%	4.5%	8.5%	4.9%
	Wasambo	Count	5_a	6_a	7_a	18
		% within WaterSource	5.7%	9.0%	9.9%	8.0%
	Macheliyili	Count	3_a	1_a	1_a	5
		% within WaterSource	3.4%	1.5%	1.4%	2.2%
	Kubbagmado	Count	7_a	6_a	3_a	16
		% within WaterSource	8.0%	9.0%	4.2%	7.1%
	Frigmagdo	Count	6_a	4_a	7_a	17
		% within WaterSource	6.9%	6.0%	9.9%	7.6%
	Tuya	Count	4_a	1_a	2_a	7
		% within WaterSource	4.6%	1.5%	2.8%	3.1%

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Namoni	Count	9_a	5_a	6_a	20
	% within WaterSource	10.3%	7.5%	8.5%	8.9%
Binagmando	Count	9_a	2_a	4_a	15
	% within WaterSource	10.3%	3.0%	5.6%	6.7%
Motondo	Count	16_a	8_a	9_a	33
	% within WaterSource	**18.4%**	11.9%	**12.7%**	14.7%
Nanyinku	Count	4_a	4_a	4_a	12
	% within WaterSource	4.6%	6.0%	5.6%	5.3%
Bungbali	Count	7_a	5_a	4_a	16
	% within WaterSource	8.0%	7.5%	5.6%	7.1%
Total	Count	87	67	71	225
	% within WaterSource	100.0%	100.0%	100.0%	100.0%

Each subscript letter denotes a subset of Water Source categories whose column proportions do not differ significantly from each other at the .05 level.

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Energetic Potential of the Biogas from Urban Solid Waste Generated in the Jacareí Municipal Landfill, Brazil

By Francielle da Silva Leandro & Rosana Teixeira Miranda

Federal University of Itajubá - UNIFEI

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Keywords: *waste to energy (WtE), global warming, clean development mechanism (CDM), power generation.*

GJSFR-H Classification: *DDC Code: 662.88 LCC Code: TP360*



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Energetic Potential of the Biogas from Urban Solid Waste Generated in the Jacareí Municipal Landfill, Brazil

Francielle da Silva Leandro [α] & Rosana Teixeira Miranda [σ]

Abstract- The use of biogas from solid waste is a way to produce renewable and clean electric energy and presents itself as an alternative to make up the country's energy matrix as well as a solution to the serious problem faced by municipalities that is the accumulation of waste. In this article it was evaluated the potential of the biogas from the landfill of the municipality of Jacarei which has an estimated population of 277,800 inhabitants and a daily waste volume of around 140 ton/day. From the estimated volume of biogas produced in the landfill, about 11.43 million m^3/year at maximum production, the annual electricity generation value was 3.81 GWh. However, based on the scenarios and assumptions adopted, a possible project implementation would not be economically viable. The study reinforces that a minimum amount of waste is needed to enable this alternative as energy production purpose, but encourages other assessments within existing conversion technologies as well as signaling the need for incentives and policies that make such projects viable. The positive result of the study is achieved when the greenhouse gas emissions (GHG) avoided is analyzed, since methane (CH_4) and carbon dioxide (CO_2) are gases that most contributes to the GHG effect.

Keywords: waste to energy (WtE), global warming, clean development mechanism (CDM), power generation.

I. Introduction

The production of solid waste has become a serious problem for public administrations. The lack of planning and housing policies contributes to the disorderly occupation of cities and to the emergence of inappropriate waste disposal sites and the appearance of dumps.

In Brazil, the National Solid Waste Policy (Federal Law 12305/2010) [1], was processed for more than 20 years in Congress before its approval and use in 2014. In accord to this policy, solid waste must be treated in landfills.

Several available technologies around the world permit recovering energy from solid waste. Brazil has great potential for using solid waste as an energy source, even on a small scale would support in the long term a strategy of expanding the country's supply of electricity or biofuel.

There is a worl concern with reducing the atmospheric concentration of greenhouse gas (GHG) that encourages the public sector to establish laws and investment in renewable energy.

The objective of the present study is to quantify the potential of the methane gas in generating electricity. The study will consider the biogas from the solid waste disposed in landfill located in the muncipality of Jacareí-SP, analying the economic feasibility of implementing a biogas plant considering the revenues obtained from the commercialization of the generated energy. As a secondary objective, the avoided GHG emissions will be calculated from possible scenarios for the disposal of solid waste.

a) Solid waste situation in Brazil

Currently, Brazil has a Federal Law 12305/2010 [1] that establishes guidelines for the National Solid Waste Policy (PNRS). Until the establishment of the PNRS, other laws dealt with this matter. However the PNRS came to regulate the final destination of the solid waste, which including urban waste, acting as a regulatory framework that brings together instruments and guidelines that the agents involved must follow.

In general, waste is considered any material that, after its use, has lost its primary functionality. According to the Brazilian Standard NBR 10004 [2], it is also considered as municipal solid waste (MSW) the sludge residues from the sewage treatment plant (ETE), those generated in equipment and installations to control pollution and liquids, which due to some particularity, they cannot be released into public sewers or water bodies. According to Federal Law 12305/2010 art. 13[1] the solid waste can be origined for:

- Urban solid waste, those originating from domestic activities in urban homes and those originating from sweeping, street and public roads cleaning and other urban cleaning services;
- Commercial establishments and service providers activities;
- Public basic sanitation services activities;
- Industrial generated by transformation processes and activities;
- Health services waste, those defined in accordance to regulations or norms established by supervisory bodies;
- Civil construction waste, those generated in constructions, renovations, repairs and demolitions

Author α σ: Master in Energy Engineering, Federal University of Itajubá – UNIFEI. e-mail: rosana_miranda@hotmail.com

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of civil works, including those resulting from excavation for land preparation and civil works;

- Agricultural, arising from the productive activity of the primary sector.
- Transport services waste, those originating from ports, airports, customs, road and rail terminals and border crossings; or
- Mining waste, those generated in the activity of research, extraction or mineral processing

In this article, only urban solid waste will be treated.

According to ABRELPE [3], the total ammount of waste generated in Brazil in 2019 was 79 million ton/year. About 92.0% of this total was collected. The Fig. 1 compares the percentage of waste disposal that had an adequate final destination (landfills) and inadequate final destination (disposed in controlled landfills and dumps), concluding that about 5 million ton/year were still not collected.

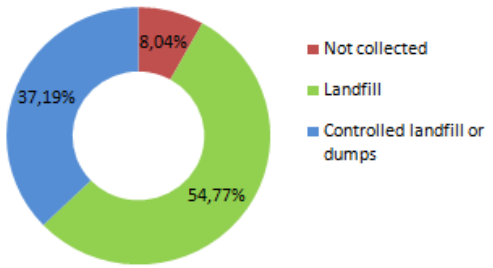

Fig. 1: Final destination of MSW collected in Brazil in 2019 (ton/year) [3]

The initial deadline of the PNRS for the municipalities eradicating irregular landfills and effectively implemented the solid waste management expired in 2014. In 2020 a new deal was established: all capitals and metropolitan regions must eliminate dumps until August 2021; cities with more than 100,000 inhabitants have until August 2022 and for those with less than 100,000 inhabitants the deadline is August 2024. Recycling collection and material separation are significant components of MSW minimization. However is important to highlight that only 73.10% of the municipalities carry out selective waste collection as shown in Fig. 2.

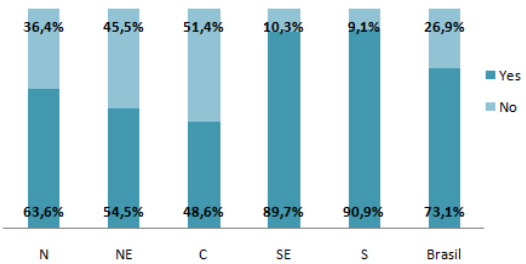

Fig. 2: Selective waste collection in municipalities in 2019 – Regions and Brazil [3]

b) The problem of urban solid waste and its energy use

The decomposition of materials could generate toxic gases that contaminate the soil, water, air and population [3], so the inadequate destination of residues is responsible for serious environmental impacts.

Disposal in landfills remains the main form of MSW disposal method. However, it is known that landfills are major contributors to the emission of GHG. An alternative to minimize its effect is the energy use of MSW for energy generation [4]. Solid waste gases are composed of 50% to 60% methane (CH_4), 40% to 50% carbon dioxide (CO_2) and smaller proportions of other gases such as ammonia (NH_3), hydrogen (N_2) and oxygen (O_2) [5]. These gases are generated during the decomposition of organic matter that occurs by two processes: aerobic decomposition, from the final disposal of waste in the landfill, and anaerobic decomposition, due to the reduction of O_2. CH_4 and CO_2 come from anaerobic decomposition [6], both are responsible for GHG emissions. CH_4 is the second most important GHG emissions, after CO_2 and its global warming potential is 21 times greater than CO_2 [7].

Therefore it is fudamental analyzing the feasibility of implementing plants for the energy use of MSW as an environmental alternative and as a business opportunity. Incineration and biological processing of MSW are examples of energy use that can drastically reduce the area needed for landfills [6]. Recycling is also considered an efficient form of energy use, as it allows the recovery of raw materials used in the production process, where energy consumption is normally higher. The energy use from biogas, commonly known as landfill gas (LFG), can be used in two ways: as a substitute or complement to natural gas, in this case a purification process is need [8], or as electricity generation that will be the object of this study [6].

c) Electricity generation from biogas

The energy use of biogas for electricity generation requires the installation of equipment to operate and monitor the system as shown in Fig. 3.

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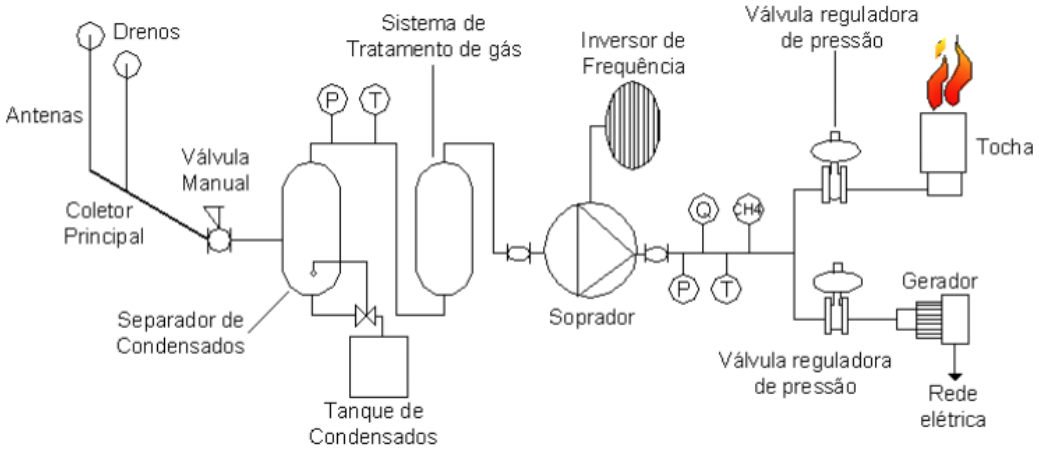

Fig. 3: Simplified diagram of biogas capture and treatment process [9]

Landfilling as a method of MSW disposal management does not contribute to a significant reduction in the volume of accumulated waste. Other alternatives, as incineration for example, are more efficient for reduce the amount of wastes that go to landfills. The continuous disposal of waste will definitely end up depleting the landfill's volume capacity.

Investments into plant of producting electricity from energy recovery of biogas should be considered important strategies for energy policies: as renewable energy sources and as an added benefit of avoid GHG emissions. The government should make more efforts to promote improvements, incentive programs, laws and policies. The Federal Law 10438/2002 [10], for example, has the objective of expanding the use of renewable energy. Through the Federal Law 9427/1996 [11], public or private companies that operate the landfill can organize itself as a self-producer or independent producer.

Two normative could also improve the economic viability of producing electricity from MSW: revenues from the sale of electricity or in the compensation scheme, with permit a reduction in the value of the electricity bill, as provided the Normative Resolution 687/2015 [12]; free fee of use of electrical transmission and distribution systems, as characterized in the Normative Resolution 271/2007 [13].

II. Materials and Methods

The option adopted to select the municipality of Jacarei to be addressed in this study was based on the document "Study on the potential of energy generation from waste (garbage, sewage)", in order to increase the use of biogas as an alternative of renewable energy source [14]. These criteria take into account the population data of the city (population greater than 200,000 inhabitants), as well as the minimum amount of waste necessary to enable projects to recover biogas from landfills for the purposes of energy generation and biogas production. It is also considered a potential production for a period of at least fifteen years.

As this study intend to evalution the potential for producing biogas from urban solid waste for generate eletricity purpose, the data needed are: waste demand, considering population growth, year of start and end of waste disposal, gravimetric composition of the waste, climate, temperature and rainfall in the city, among others. These informations were based on the Municipal Plan for Integrated Solid Waste Management – PMGIRS referring to the municipality of Jacarei [15].

a) Characterization of the municipality of Jacareí

The municipality of Jacareí is located in the Paraíba Valley, between Rio-São Paulo, 80 km from the capital of São Paulo and 350 km from Rio de Janeiro. The area is 464 km^2. The latitude and longitude coordinates are: - 23° 18' 10' south and - 45° 17' 31" west. Its altitude varies between 567 to 730 meters. The time zone is UTC-3. The population according to 2010 census was 211,214 thousand inhabitants. The city's climate is tropical from altitude to subtropical, with dry winter. The temperature presents an annual average of 21°C. July is the coldest month, temperature around 13°C and Februar is the hottest, temperature around 25°C. The annual rainfall index is around 1.475mm.The geographic location is shown in Fig. 4.

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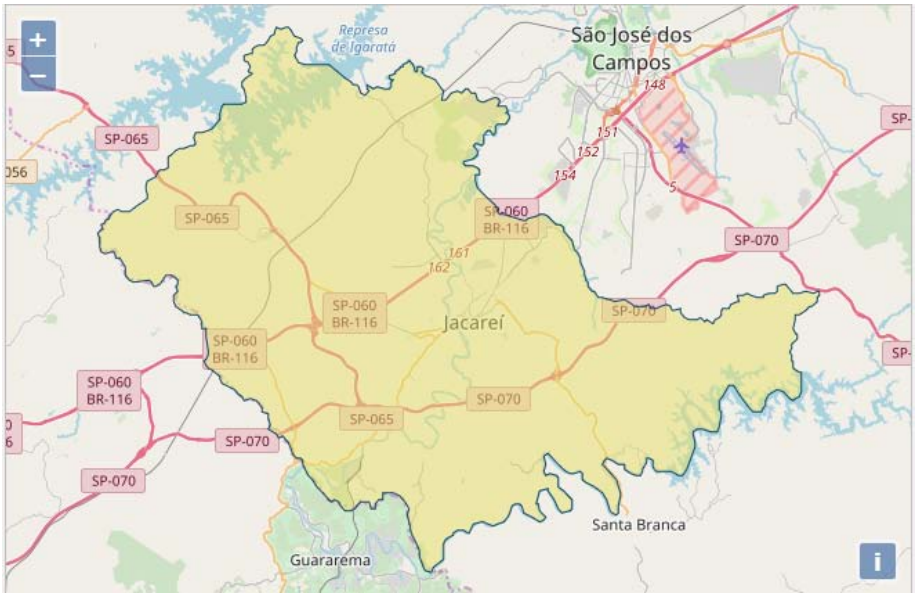

Fig. 4: Geographic location of Jacareí [15].

Two order municipalities, São Silvestre de Jacarei and Parque Meia Lua, make part of Jacarei. The economy is based on three sectors of activities: agriculture (0.39%), industry, (51.74%), and services (47.87%).

b) Landfill and useful life

The landfill has an area of 792,550 m² located at a geographic coordinates N = 7,422,300 and E = 406,100. The landfill operation started in 2018 and it was projected to receive the household waste until 2040 but its useful life can be greatly increased with the recycling of waste. The MSW volume should be gradually reduced with the implementation of the environmental education plan, sorting unit, selective collection and the operation of the biodigestion plant.

c) Population data

The demand for urban cleaning services and MSW management services is calculated as a function of the population growth projection. The PMGIRS of Jacarei presents this projection with a 25-year horizon: it starts in 2015, the year of the forecast for the beginning of the actions foreseen in the PMGIRS and runs until 2040. The population growth of Jacarei accelerated with industrialization. The growing development of industries has led to boosted migration to the municipality, mainly in urban areas. Analyzing the data presented in the PMGIRS of Jacarei, it is possible to see that the urban population represents 98.62% while the rural population is 1.38%. Table 1 shows the estimated projection from 2020 to 2040 (expected year of landfill useful life) according to the PMGIRS of Jacareí.

Table 1: Population projection of the Jacarei municipality [15].

Year	Estimated population	Year	Estimated population
2018	228,358	2030	256,801
2019	230,600	2031	259,329
2020	232,864	2032	261,883
2021	235,151	2033	264,463
2022	237,461	2034	267,068
2023	239,794	2035	269,700
2024	242,151	2036	272,359
2025	244,532	2037	275,044
2026	246,937	2038	277,756
2027	249,366	2039	280,496
2028	251,819	2040	283,263
2029	254,297		

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The population projected in the PMGIRS was made from the analysis of census data and using the geometric method. According to the PMGIRS, this method is most suitable due to the rapid growth of the municipality and its size, with a growth rate of 1.01% per year for the total population and 0.99 % per year for rural population. The geometric method can be used, in most cases, when the municipality is in a phase of accelerated growth, as seen in Jacareí and generally follows the exponential curve. The formula that calculates the projection is given by equations (1) and (2):

$$P = P_0 * q \quad (1)$$

$$q = (P / P_0)^{\wedge (1/t-t_0)} \quad (2)$$

Where:
q - geometric growth rate;
P_0 - initial population based on the last known census;
t_0 - year of the last census;
P - final population or that of the desired year;
t - desired year (projection horizon).

d) Per capita generation of urban solid waste in Jacarei muncipality

The per capita generation of solid waste is the daily amount of waste generated by each inhabitant [16]. Based on a survey carried out with the population, the PMGIRS elaborated the projection of demand for the urban solid waste and established short, medium and long-term goals for the amount of waste generated per capita, which are shown in Fig. 5.

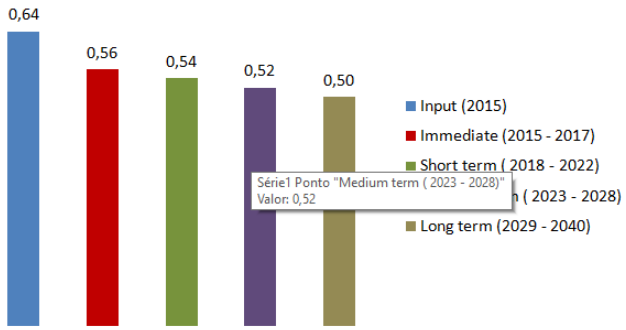

Fig. 5: Targets per capita for the urban solid waste generation (kg/inhabitant day) [15]

The population projection of Jacarei muncipality and the quantities of urban solid waste generated will permit the subsequent calculation of the methane production. The Fig. 6 was elaborated from the data informed in the PMGIRS.

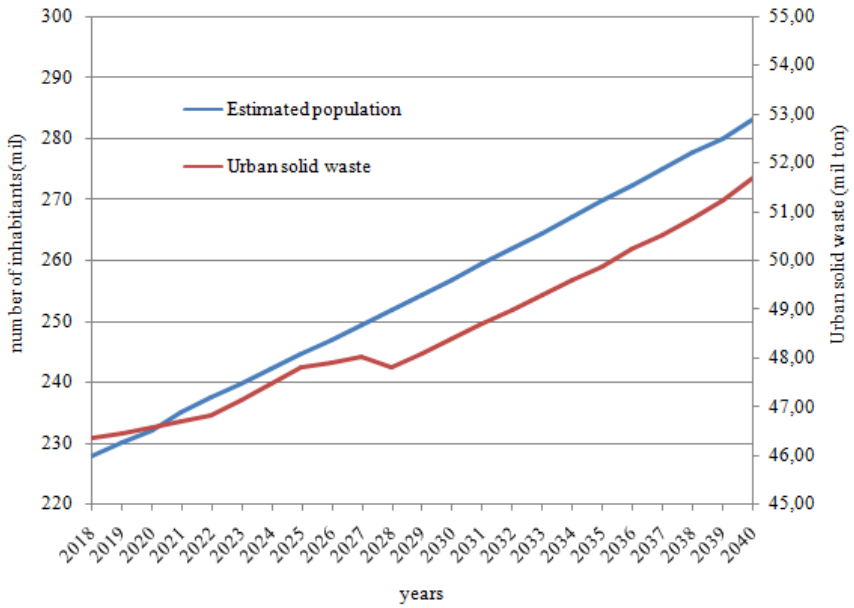

Fig. 6: Population projection and waste generation

e) Urban solid waste characterization

The composition of solid waste is influenced by several factors: number of inhabitants, purchasing power, educational level, habits and people's custom, climate conditions, changes in the country's economic policy [6]. According to the PMGIRS of Jacarei, which based on data from the Department of the Environment of the Municipality of Jacareí, the characterization of urban solid waste in the municipality is as presented in Table 2.

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Table 2: Urban solid waste solid characterization of the Jacarei municipality

Composition	Weight (ton/month)	%
Recyclable	89.51	2.17%
Household waste	4,037.32	97.83%
organic	3,216.08	77.93%
waste	821.24	19.90%
Total	4,126.83	100.00%

f) Waste Reduction Model (WARM)

The Waste Reduction Model (WARM) was created by the United States Environmental Protection Agency (EPA) [17] and allows reporting of GHG reductions from different waste management practices such as source reduction, recycling, anaerobic digestion, combustion, composting and landfill. In this work, version 12 of the tool available on the EPA website was used. The metric for emissions results is relative to the measurement of one ton of CO_2 equivalent ($MTCO_{2eq}$).

Based on the waste characterization presented in Table 2 it was possible to develop different scenarios to different solid waste management practises.

The mass of waste used will be the estimated production in 2040 acording to population projection and waste generation presented in Fig. 6. As 2.17% of the waste is recycled, the baseline scenario (Fig. 7) will consider this part of recyclables and the landfill of organic waste and of the tailings. It will be analyzed 3 scenarios according to Fig. 8; Fig. 9 and Fig. 10.

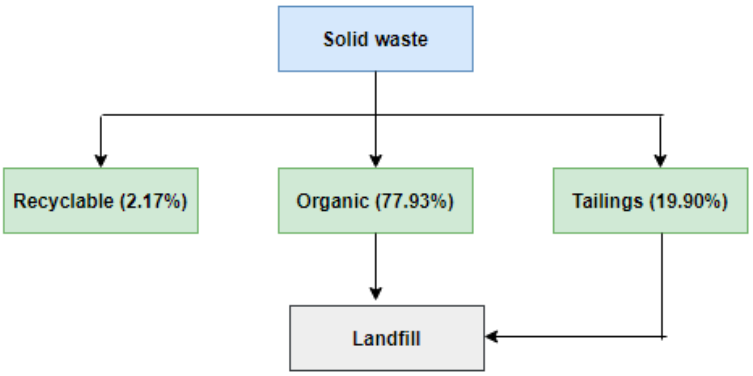

Fig. 7: Schematic summary of scenario baseline

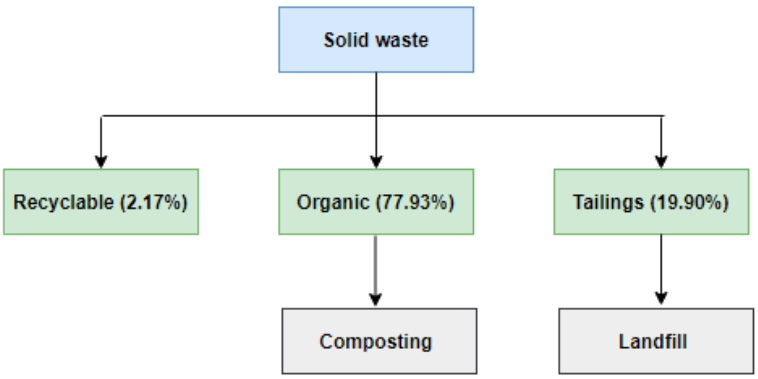

Fig. 8: Schematic summary of scenario 1

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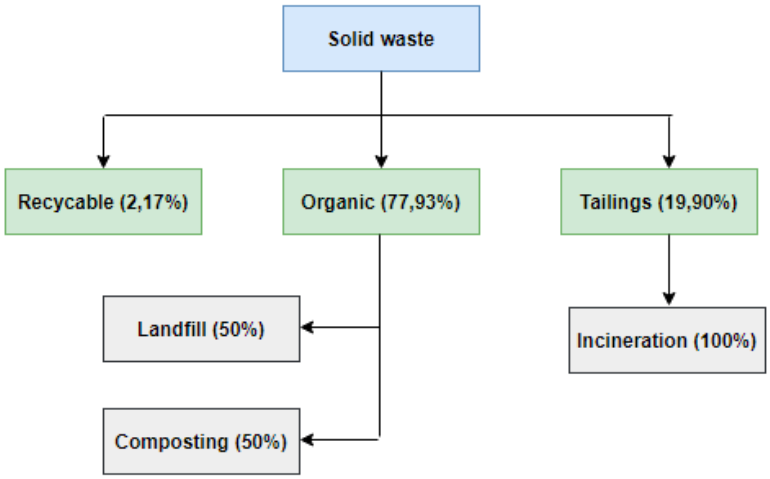

Fig. 9: Schematic summary of scenario 2.

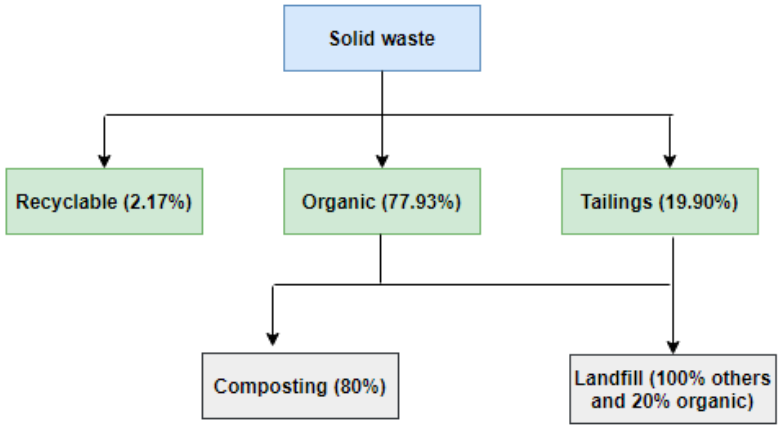

Fig. 10: Schematic summary of scenario 3

g) Land GEM

There are theoretical and experimental formulations to determine the potential of gas generation from landfill. The experimental ones consider the real measurements and therefore their determination is more difficult. In this work, the theoretical formulation will be used. In Brazil there is no developed methodology that takes into account local peculiarities, such as waste composition, climate and landfill operation. The model adopted for this study, the software Land GEM (Landfill Gas Emissions Model), is a program developed by EPA [18]. In this model the standard inventory and parameters were developed from empirical data from US MSW landfills. Land GEM accounts the amount and variations in landfill gas generation, calculating the emission of CH_4 and the emission of 49 other components, including CO_2. The Land GEM equation in version 3.02 considers the generation of methane with an increment of 0.1 each year, producing a small reduction in the estimated emissions compared to previous versions [19].

h) Calculation of the CH_4 emissions

The Land GEM model uses equation (3) to calculate the estimated annual emissions for the specified period.

$$Q_{CH4} = \sum_{i=1}^{n} \sum_{j=0,1}^{1} k.L_0 \left(\frac{M_t}{10}\right).e^{-k.t_{i,j}}$$

Where:

Q_{CH4} - annual methane generation in the year of the calculation (m^3 /year);

i =1 - year time increment;

n - corresponds to the year of the calculation (initial year of opening of the landfill);

j = 0.1 - year time increment;

k - methane generation rate (year-1);

L_0 - methane generation (m^3/ton.);

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Mt - mass of waste received in the year in each section (ton.);
$t_{i,j}$ - corresponds to the year, in each section, of receipt of the mass of waste (time with decimal precision).

The parameters L_0 and k are the most important, as they reflect variations according to location, climate and type of waste. Theoretically, the k factor varies from 0.003 to 0.21 ($year^{-1}$). According to IPCC [20], the most rapid rates (k = 0.2) are associated with high humidity site conditions and rapidly degradable waste such as food waste. The slower rates of decomposition (k = 0.002) are associated with dry site conditions and slowly degradable residues such as wood or paper. The Land GEM model suggests a k value of 0.05 as a default value. On the other hand, the L_0 factor is proportional to the percentage of organic materials present in the waste, and it can range from 0 (lack of degradable material) to 300 m^3/ton[21]. The default used by Land GEM is a Lo value of 170. Table 3 shows the values recommended by the EPA, the World Bank and the values adopted by the Land GEM model for k and L_0.

Table 3: K and L_0 values

Parameters	EPA	World Bank	LandGEM
k ($year^{-1}$)	0.04	0.06	0.05
L_0 (m^3CH_4 .t_{MSW}^{-1})	100	170	170

In the model adopted by the Land GEM, the default CH_4 and CO_2 content of LFG is 50% for both.

i) Calculation of power and energy

Once the volume of CH_4 was determined through Land GEM it is possible to estimate the power and energy. According to [22], the most used technology for recovering energy from biogas is the internal combustion engines (MCI) due to its economic feasibility. The computer program developed by [23] uses the equations (6) and (7) to estimate the power and energy. The parameters used by this program are in Table 4.

$$P = (Q_{CH4} * PCI_{CH4} / 31{,}536{,}000) * \eta * Er * c \quad (6)$$

Where:
P - available power per year (MW)
Q_{CH4} - annual methane flow (m^3/year)
PCI_{CH4} - calorific value of methane (J/m^3)
31,536,000 - Seconds in a year (s/year)
η - energy conversion efficiency according to the chosen technology (%)
Er - landfill gas recovery efficiency (%)
$c = 10^{-3}$

$$E = P * 8760 \quad (7)$$

Where:
E - energy available per year (MWh)
8760 - hours in a year (h/year)

Table 4: Parameters for calculating the energy use of biogas

Parameters	Value
CH_4 percent by volume of biogas (%)	50
CH_4 recovery index (%)	75
Engine efficiency	0,2

Santos et al. [24] study determines as optimal power, for the dimensioning of a generator set at full load, the value of 45% of the maximum potential.

j) Feasibility Analysis

The economic viability analysis of installing a LFG plant from the landfill in the municipality of Jacareí will be carried out from the net present value (NPV). According to [25], NPV consists on determining the present value of a future values cash flow, discounted at an internal rate of return (IRR). If the present value is positive, the project is attractive and the higher is the positive value, the more attractive is the project.

$$NPV = \frac{FC_0 + FC_1/(1+j)^1 + \ldots + FC_t}{(1+j)^t}$$

Where:
FC = cash flow of the nth year, in U$;
j = discount rate (%);
t = project lifetime, in years

For the study a period of 20 years was considered, which corresponds to the lifetime of the installation. During this period it will be possible to observe the attractiveness of the project. An IRR of 8% per year was chosen to discount the annual cash flow and calculate the NPV.

The estimed costs for implementation, operation and maintenance (O&M) based on [26] and the reference values in dollar are shown in the Table 5.

Table 5: Installation and O&M costs [26].

Component	Un.	Value (U$)
Preliminary studies	un	12.500,00
Design	un	10.000,00
LFG collection and flare system	un	1.143.000,00
Purchase and installation of equipment	kW	2.400,00
O&M (collection) annual	un	191.000,00
O&M (installation) annual	kW	160,00

It will be considered a financing of 75% of the value of the investment, with an interest of 2.50% per

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year, depreciated by the PRICE amortization system in 10 years. The interest rate consider as reference is those practiced by the National Development Bank (BNDES) in credit operations for infrastructure projects of expansion and modernization of energy generation from renewable sources [27].

The sale of energy generated by the treatment plant will be considered as monthly revenue. The kWh cost is U$ 0.11. Its reference is the average cost of R$ 0.58/kWh in 2020 taken from [28] and converted to the average quotation of the dollar in reais (R$ 5.15) of the same year in according to BACEN [29].

III. Results and Discussion

a) *WARM Results*

The results of the WARM for different model scenarios are shown in Table 6 e 7. It is possible to observe that scenario 2 presented better results in terms of GHG emissions, showing a reduction in emissions of 102,494.35 of MTCeq and 375,812.60 of $MTCO_{2eq}$. In addition, this scenario had a greater increase in energy savings of 826,748.03 million BTU, which is equivalent to 142,297 barrels of oil or 6,613,984 gallons of gasoline.

Scenario 1 was presented an intermediate results, wtih a saving in GHG and energy emissions. Analyzing GHG emissions, there was a reduction of 97,394.35 MTC_{eq} and 357,114.46 $MTCO_{2eq}$, therefore, less significant than in scenario 2. However, there was an energy increase of 147,740.73 million BTU.

Scenario 3 was less satisfactory. Comparating this scenario with the baseline, there was a reduction in GHG emissions, but the emissions were still higher than scenarios 1 and 2. Furthermore, an increase in energy use of 118,192.59 million BTU was observed, equivalent to 20,340 barrels of oil or 946,541 gallons of gasoline.

Table 6: WARM results – Total energy use

	Scenario 1	Scenario 2	Scenario 3
Total energy use – MSW generation and management (million BTU)			
Baseline	-292.995,89	-292.995,89	-292.995,89
Alternative Management	-145.255,15	-1.119.743,92	-174.803,30
Incremental energy use	147.740,73	-826.748,03	118.192,59

Table 7: WARM results – Total GHG emission

	Scenario 1	Scenario 2	Scenario 3
Total GHG emission - MSW generation and management ($MTCO_{2eq}$)			
Baseline	331.426,25	331.426,25	331.426,25
Alternative Management	-25.688,21	-44.386,35	45.734,68
Incremental GHG emission	-357.114,46	-375.812,60	-285.691,57
Total GHG emission - MSW generation and management (MTC_{eq})			
Baseline	90.388,98	90.388,98	90.388,98
Alternative Management	-7.005,88	-12.105,37	12.473,09
Incremental GHG emission	-97.394,85	-102.494,35	-77.915,88

b) *Land GEM Results*

The Land GEM model project the curve of CH_4, CO_2 and NMOC emissions and the biogás production (Fig. 11). It is worth noting that as the model considers the same proportions of CH_4 and CO_2 in the composition of the biogas, the curves of these emissions coincide. The total gas emissions increase noticeably in the period from 2018 to 2040 (from the open landfill to the closure landfill). At the end of landfills useful life (2040) the total of biogas emissions reaches 11.11 million m^3/year, with 5.55 million m^3/year corresponding to CH_4 emissions. When the waste disposal operations in the Jacarei landfill end, it is interesting to note that gas emissions do not cease immediately, but they start to present a sharp decline. Residual biogas emissions take many years to completely stop. It is known that these gases can cause damage to the environment, as well as to human health. Therefore it is necessary to monitor the landfill area even after its closure, avoiding possible accidents in the area.

The Land GEM model identify the peak production of CH_4 and biogas generation as a year after the end of waste disposal in the landfill (2041), with a value of 5.71 million m^3/year to CH_4 emissions and 11.43 million m^3/year to biogas production. The maximum power generated was calculated from this volume of biogas with a value of 966 kW (Fig. 12). The optimal power was found using 45% of the maximum power thereby obtaining the energy (Table 8).

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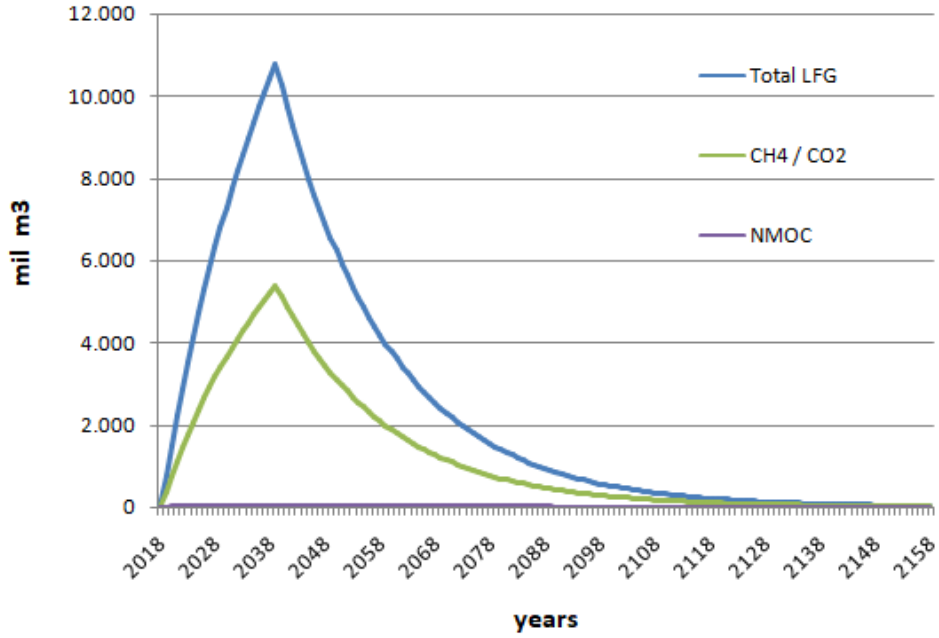

Fig. 11: Total gas emissions by total biogas (LFG)

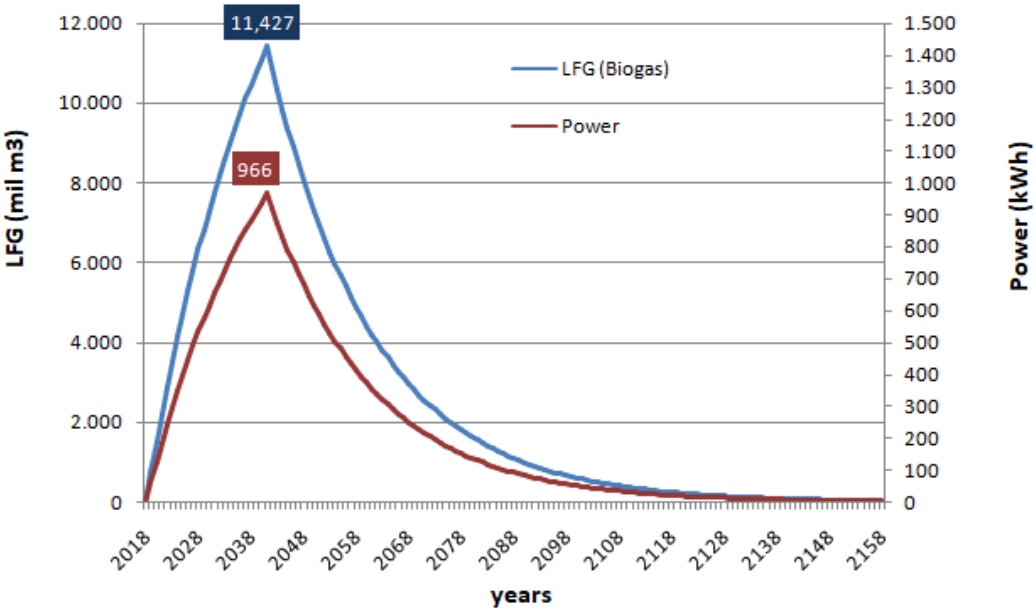

Fig. 12: Biogas evolution and Power

Table 8: Optimum power and energy

Power (kW/year)	Energy (kWh/year)
434,51	3,806,337.14

Table 9: Economic analysis of the biogas energy use

Investiment (U$)	O&M (U$/year)	Revenues (U$/year)	NPV
2,208,332.09	260,522.14	427,844.10	-139,886.28

c) Economic viability

Based on the implementation costs, O&M costs and revenues values, the cash flow and NPV for the biogas plant project were calculated. These values are presented in Table 9.

The energetic use of biogas from MSW failed to present satisfactory values. The revenues from the sale of energy generated over the lifetime of the project do not exeeced the capital investments and operational costs. It is revealed by a negative NPV values.

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Thus, the result confirm one of the major challenges facing in this project is required a minimum volume of MSW for LFG energy use. The investiments required do not make economic sense at small volumes of MSW as already concluded by some authors. The Tolmasquim's estimate [30], for example, it would be around 300 t RSU/day. This is due to the low volume of CH_4 present in the biogas, generally assumed to be a percentage of 50.

IV. Conclusion

The study contributed to reinforce the need to assess and determine the risks of implantating biogas plant projects for energy use. It is strongly recommended that the decision be based on technical and economic feasibility studies. In addition to the balance between income and expenses, future studies indicate the need to use different models to determine the biogas production which should take into account the waste composition and characteristics, climate and other local characteristics.

In most municipalities the volume of MSW are relatively small, thus, alternatives such as involving partnerships between them is need in order to ensure a reasonable volume of waste that become energy use viable. Finance policies and incentives for researching and developing new technologies of low costs would be welcome and would contribute to enhance economically the projects' viability.

The benefit of emissions avoided wiht the energy recovering was not evaluated in this study, disregarding economically the probable revenues from the sale of carbon credits.

The composting and incineration are practices of waste management that as observed in scenario 2 can contribute to reducing GHG emissions and energy savings. It is worth highlighting the use of renewable source instead of fossil resource generate positive impacts to the environment. Other positive aspect is the impact that this kind of project on job creation for the local population. Thus, the environmental and social aspect of energy production from landfill biogas represents the positive part that can make its implementation feasible.

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By Kafu R., Almasri T. & Ghenghish M.

University of Tripoli

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الملخص- في هذه الدراسة تم عزل وتعريف 20 نوع من الفطريات البحرية الكيسية و 4 أنواع من الفطريات البحرية الناقصة المصاحبة للأخشاب وريزمات الأعشاب البحرية الرطبة و المقذوفة على شواطئ ليبيا الغربية. 5 أنواع منها تم تسجيلها لأول مرة في ليبيا مع كتابة نبذة مختصرة عن الأنواع التي تم تسجيلها في هذه الدراسة.

Keywords: *driftwood, phanerogamic debris, marine fungi, ascomycetes.*

GJSFR-H Classification: *DDC Code: 589.2 LCC Code: QK601*



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Lignicolous Marine Fungi from Libya

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Abstract- Examination of driftwood and landed phanerogamic debris found loose on sea shores along the western coast of Libya, yielded (20 species) of marine fungi. Ascomycetes (16) and (4) Hyphomycetes . (5) Species of these were reported for the first time in Libya. Brief descriptions of the recorded species are presented.

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I. Introduction

The role of marine fungi associated with plant debris in marine and aquatic habitats is immense and they are responsible for the most of the decomposition of organic materials, thus contributing in nutrient regeneration cycles (1). Marine fungal taxa have been isolated from submerged woody substrates in marine habitats(2)(3)(4)(5)(6). Few studies have been carried out to document lignicolous marine fungi from African shores of Mediterranean Sea. Most collections have been made predominantly in southeast of Asia, Europe, and North America (7). However there is little information on marine fungi from Libya (8) and North Africa (9). The present work would commence with traditional approach to such problem that is collection, identification and description of the organisms.

II. Materials and Methods

To collect marine lignicolous fungi, the remains of drift wood and phanerogamic plants remains found loose on the sea shores were collected from several locations along the western coast of Libya in sterile plastic bags and brought to the laboratory, rinsed with tap water, placed on moist filter papers in glass chambers and incubated at room temperature for (4-8 weeks). Samples were examined periodically for any fungal growth. These were then transferred to slides for examination under light microscope. Lacto phenol cotton blue mounts of squash fungal fruit bodies were prepared for permanent specimens. The recorded fungi were identified using morphological traits (3) (4) (5).

III. Results

Table 1: Shows the fungal species identified

Class	Ascomycetes
1. Family	Halosphaeriaceae
Species	(11)
	1. *Arenariomyces majusculus* Kohlm
	2. *Ceriosporopsis cambrensis* Wilson
	3. *Ceriosporopsis halima*, Linder
	4. *Corollospora gracilis* Nakagiri & Tokura
	5. *Corollospora maritima* Werderm
	6. *Halosarpheia fibrosa* Kohlm
	7. *Halosphaeria circumvestita* Kohlm
	8. *Halosphaeria maritima* (Linder) Kohlm
	9. *Halosphaeria mediosetigera* Cribb
	10. *Lulworthia medusa* (Ellis & Everh) Cribb & Cribb.
	11. *Toorpedospora radiata* , Meyers
12. Family	Pleosporaceae
Species	5
	1- *Halotthia Posidonia* (Durieu&Mont.)Kohlm
	2-*Leptosphaeria albopunctata* (west) Kohlm
	3- *Leptosphaeria orea - maris* Linder
	4- *Pontoporeia biturbinata* (Durieu&Mont.)Kohlm
	5- *Verroculina enalia* Kohlm
1. Class	Deuteromycetes
1. Family	Dematiaceae
Species	4

Author α σ: Department of Biology. Faculty of Education. University of Tripoli. Tripoli/ Libya. e-mail: Ra.kafu@uot.edu.ly
Author ρ: Marine Biology Research Center, Tajura, Libya.

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	1-*Cirrenalia macrocephla* (Kohlm.) Meyers & Moore
	2- *Dendryphiella arenaria* Nicot
	3- *Dictyosporium pelagicum* (Linder.)Hughes
	4- *Zalerion maritima* (Linder.) Anastasiou

IV. Taxonomy and Description

Class: Ascomycetes

a) Family: Halosphaeriaceae

Species (11)

With exclusively marine taxa generally have deliquescing asci and diverse spores/ spores appendage morphology.

1. *Arenariomyces majusculus Kohlm.*
Ascospores hyaline (8) 10 -14×30 μ, 2- celled and with 3-4 terminal appendages at each end. Previously reported El-khoms and Misurata (8).

2. *Ceriosporopsis cambrensis Wilson.*
Ascospores hyaline 2- celled, 1-- terminal thin filiform deliquescent appendage at each end, up to 45 μ long. New reports from Libya.

3. *Eriosporopsis halima, Linder.*
Ascospores hyaline 2- celled 6–8 × 18-26 (30) μ with terminal appendages, one at each end, filiform 8 μ long and thick at base. Previously reported in Tripoli (10).

4. *Corollospora gracilis Nakagiri & Tokura.*
Ascospores hyaline 2-celled 1-4 × 20-μ with single stiff appendage at each end ribbon shaped setae around the septum. Previously reported from Zuwara(8).

5. *Corollospora maritima Werderm.*
Ascospores hyaline, one septate, 8-10 ×26-34 excluding appendages. One slender appendage at each end and several hairs like equatorial appendages. Previously reported from Susa , Misurata, El Khoms , Tajoura , Tripoli and Zuwara (8).

6. *Halosarpheia fibrosa Kohlm.*
Ascospores 2- celled 14-16 × 23-36 μ with cap like appendage at each end, almost transforming into delicate ligament .previously reported from Zuwara (8).

7. *Halosphaeria circumvestita Kohlm.*
Ascospores hyaline, 2- celled, 9-12×22-30 μ, surrounded by an irregular lobed mucilaginous sheet. First reports for Libya.

8. *Halosphaeria maritima (Linder) Kohlm*
Ascospores hyaline 2- celled, 8-12×18-26 μ, One subgelatinous yoke - shaped at each end. Previously reported from Misurata (8).

9. *Halosphaeria mediosetigera Cribb.*
Ascospores hyaline, 2- celled, 8-16 × 28-34 μ, around the septum attached more than one crescent shaped stiff appendage. Previously reported from Tripoli (10).

10. *Lulworthia medusa (Ellis & Everh) Cribb & Cribb.*
Ascospores hyaline, 4-6× (110)160 -216 μ, filiform non septet with apical mucus filled chambers or processes. First reports from Libya.

11. *Toorpedospora radiata, Meyers*
Ascospores hyaline, triseptate, 4-8, 5×36-40 μ, Provide d with 3 slender appendages on the lower end. Previously reported from Tajoura , Tripoli and Susa (8).

b) Family: Pleosporaceae

Species: (5)

Marine fungi In the Family Pleosporaceae mostly belong to some well known terrestrial genera such as Leptosphaer species. While others are known only from marine habitats.

1. *Halotthia Posidonia (Durieu&Mont.)Kohlm.*
Ascospores 1 - septate, 16-20× 36-46 μ, with dark band around the septum. Previously reported from landed rhizomes of the seagrass Posidonia oceanica, Zuwara (8).

2. *Leptosphaeria albopunctata (west) Kohlm*
Ascospores yellow brown, 4-6 (8) ×22-30 μ, more than 4 cells, mostly seven cells. Previously reported from Tripoli and Tajoura (8).

3. *Leptosphaeria orea - maris Linder*
Ascospores pale brown, 6-8 ×16-22 μ, mostly one septet. Previously reported from Tripoli (8).

4. *Pontoporeia biturbinata (Durieu & Mont.)Kohlm*
Ascospores 2- celled 42-52 × 46-80 μ, black, provided with germ pores at both ends. Previously reported from landed rhizomes of the seagrass Posidonia oceanica at Zuwara (8).

5. *Verroculina enalia Kohlm*

Syn. Didymosphaeria enalia Kohlm.
Ascospores brown 2- celled, 6-8×14-20 μ . Ascospores wall covered with worth - like structures (verroculose). First reports from western coast of Libya.

Class: Deuteromycetes

Family: Dematiaceae.

Species: (4)

Family: Dematiaceae: Are mostly asexual morphs of marine Ascomycetes.

1. *Cirrenalia macrocephla (Kohlm.) Meyers & Moore.*

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Ascospores 2 to several cells curved, cells increasing in size and pigmentation from base to apex. First reports from Libya.

2. *Dendryphiella arenaria Nicot.*

NicotConidia 3 6-8×16-20*μ*, never longer than 20 *μ*, cylindrical, smooth and with distinct dark scar. Previously reported from landed rhizomes of the seagrass cymodocea nodosa in Zuwara (8).

3. *Dictyosporium pelagicum (Linder.)Hughes.*

Conidia dark brown to black, multicellular more or less arising from single cell. Previously reported from Susa, El- Koms , Tajoura , Tripoli and Zuwara (8).

4. *Zalerion maritima (Linder.) Anastasiou.*

Conidia filiform, multicellular forming a more or less regular 1- 3 coiled spiral (10).

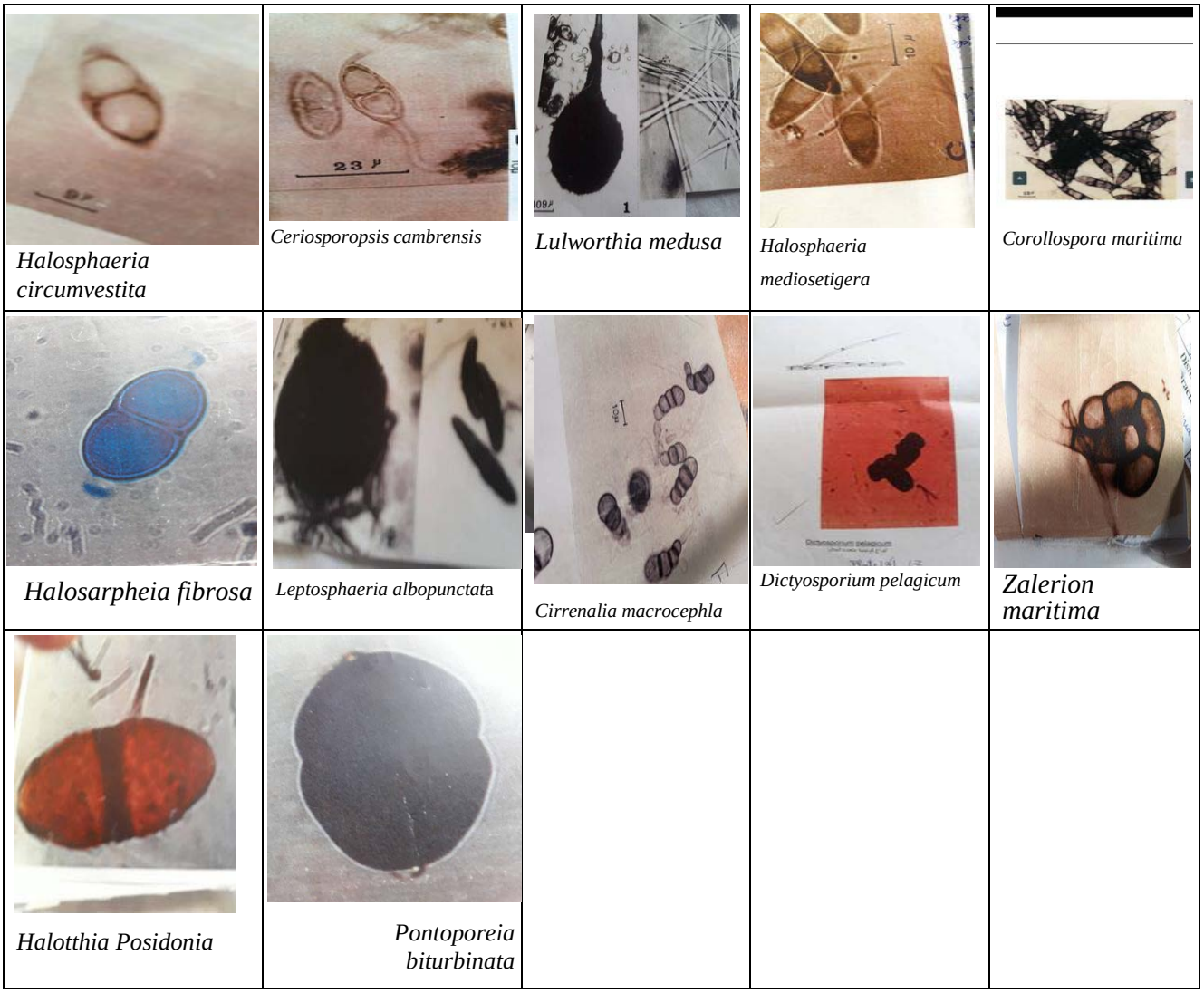

Fig. 1: Figures of most identified collected fungi in studied locations

V. Discussions

The present survey of lignicolous marine fungi reveals (11) species Halosphaeriaceae,(5) species Pleosporaceae and (4) species Dematiaceae (Table 1) (fig 1). Collecting procedure and a brief description of these fungi are also presented. (5) Species were reported for the first time in Libya: Ceriosporopsis cambrensis Wilson, Halosphaeria circumvestita Kohlm., Lulworthia medusa (Ellis & Everh) Cribb & Cribb, Verroculina enalia Kohlm (Ascomycetes) Cirrenalia macrocephla (Kohlm.) Meyers & Moore (Hyphomycetes). The new recorded Ascomycetous species, Ceriosporopsis cambrensis Wilson and Halosphaeria circumvestita Kohlm. First reports for Libya, previously reported in the Bay of Fundy and eastern coast Canada (11). Lulworthia medusa, Meyers & Moore, This species is closely related to other members of the genus, mainly L .grandispora, Meyers and Moore. The only differentiated character can be

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made on Ascospore measurement (12). Verroculina enalia Kohlm and Kohlm was the one of the frequently encountered taxon for all states and Territories investigated in India (4). The Hyphomycete Cirrenalia macrocephala, macrocephla common our collection is one of the most widely distributed marine lignicolous fungi in marine habitats (4).

VI. Conclusion

Twenty marine lignicolous marine fungi have been identified. These species belong to the classes Ascomycetes (16) and Hyphomycetes (4). Collecting procedure and brief descriptions of these species are presented. (5) Of them were reported for the first time in Libya.

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Authors can submit papers and articles in an acceptable file format: MS Word (doc, docx), LaTeX (.tex, .zip or .rar including all of your files), Adobe PDF (.pdf), rich text format (.rtf), simple text document (.txt), Open Document Text (.odt), and Apple Pages (.pages). Our professional layout editors will format the entire paper according to our official guidelines. This is one of the highlights of publishing with Global Journals—authors should not be concerned about the formatting of their paper. Global Journals accepts articles and manuscripts in every major language, be it Spanish, Chinese, Japanese, Portuguese, Russian, French, German, Dutch, Italian, Greek, or any other national language, but the title, subtitle, and abstract should be in English. This will facilitate indexing and the pre-peer review process.

The following is the official style and template developed for publication of a research paper. Authors are not required to follow this style during the submission of the paper. It is just for reference purposes.

Manuscript Style Instruction (Optional)

- Microsoft Word Document Setting Instructions.
- Font type of all text should be Swis721 Lt BT.
- Page size: 8.27" x 11'", left margin: 0.65, right margin: 0.65, bottom margin: 0.75.
- Paper title should be in one column of font size 24.
- Author name in font size of 11 in one column.
- Abstract: font size 9 with the word "Abstract" in bold italics.
- Main text: font size 10 with two justified columns.
- Two columns with equal column width of 3.38 and spacing of 0.2.
- First character must be three lines drop-capped.
- The paragraph before spacing of 1 pt and after of 0 pt.
- Line spacing of 1 pt.
- Large images must be in one column.
- The names of first main headings (Heading 1) must be in Roman font, capital letters, and font size of 10.
- The names of second main headings (Heading 2) must not include numbers and must be in italics with a font size of 10.

Structure and Format of Manuscript

The recommended size of an original research paper is under 15,000 words and review papers under 7,000 words. Research articles should be less than 10,000 words. Research papers are usually longer than review papers. Review papers are reports of significant research (typically less than 7,000 words, including tables, figures, and references)

A research paper must include:

a) A title which should be relevant to the theme of the paper.
b) A summary, known as an abstract (less than 150 words), containing the major results and conclusions.
c) Up to 10 keywords that precisely identify the paper's subject, purpose, and focus.
d) An introduction, giving fundamental background objectives.
e) Resources and techniques with sufficient complete experimental details (wherever possible by reference) to permit repetition, sources of information must be given, and numerical methods must be specified by reference.
f) Results which should be presented concisely by well-designed tables and figures.
g) Suitable statistical data should also be given.
h) All data must have been gathered with attention to numerical detail in the planning stage.

Design has been recognized to be essential to experiments for a considerable time, and the editor has decided that any paper that appears not to have adequate numerical treatments of the data will be returned unrefereed.

i) Discussion should cover implications and consequences and not just recapitulate the results; conclusions should also be summarized.
j) There should be brief acknowledgments.
k) There ought to be references in the conventional format. Global Journals recommends APA format.

Authors should carefully consider the preparation of papers to ensure that they communicate effectively. Papers are much more likely to be accepted if they are carefully designed and laid out, contain few or no errors, are summarizing, and follow instructions. They will also be published with much fewer delays than those that require much technical and editorial correction.

The Editorial Board reserves the right to make literary corrections and suggestions to improve brevity.



Format Structure

It is necessary that authors take care in submitting a manuscript that is written in simple language and adheres to published guidelines.

All manuscripts submitted to Global Journals should include:

Title

The title page must carry an informative title that reflects the content, a running title (less than 45 characters together with spaces), names of the authors and co-authors, and the place(s) where the work was carried out.

Author details

The full postal address of any related author(s) must be specified.

Abstract

The abstract is the foundation of the research paper. It should be clear and concise and must contain the objective of the paper and inferences drawn. It is advised to not include big mathematical equations or complicated jargon.

Many researchers searching for information online will use search engines such as Google, Yahoo or others. By optimizing your paper for search engines, you will amplify the chance of someone finding it. In turn, this will make it more likely to be viewed and cited in further works. Global Journals has compiled these guidelines to facilitate you to maximize the web-friendliness of the most public part of your paper.

Keywords

A major lynchpin of research work for the writing of research papers is the keyword search, which one will employ to find both library and internet resources. Up to eleven keywords or very brief phrases have to be given to help data retrieval, mining, and indexing.

One must be persistent and creative in using keywords. An effective keyword search requires a strategy: planning of a list of possible keywords and phrases to try.

Choice of the main keywords is the first tool of writing a research paper. Research paper writing is an art. Keyword search should be as strategic as possible.

One should start brainstorming lists of potential keywords before even beginning searching. Think about the most important concepts related to research work. Ask, “What words would a source have to include to be truly valuable in a research paper?” Then consider synonyms for the important words.

It may take the discovery of only one important paper to steer in the right keyword direction because, in most databases, the keywords under which a research paper is abstracted are listed with the paper.

Numerical Methods

Numerical methods used should be transparent and, where appropriate, supported by references.

Abbreviations

Authors must list all the abbreviations used in the paper at the end of the paper or in a separate table before using them.

Formulas and equations

Authors are advised to submit any mathematical equation using either MathJax, KaTeX, or LaTeX, or in a very high-quality image.

Tables, Figures, and Figure Legends

Tables: Tables should be cautiously designed, uncrowned, and include only essential data. Each must have an Arabic number, e.g., Table 4, a self-explanatory caption, and be on a separate sheet. Authors must submit tables in an editable format and not as images. References to these tables (if any) must be mentioned accurately.

Figures

Figures are supposed to be submitted as separate files. Always include a citation in the text for each figure using Arabic numbers, e.g., Fig. 4. Artwork must be submitted online in vector electronic form or by emailing it.

Preparation of Eletronic Figures for Publication

Although low-quality images are sufficient for review purposes, print publication requires high-quality images to prevent the final product being blurred or fuzzy. Submit (possibly by e-mail) EPS (line art) or TIFF (halftone/ photographs) files only. MS PowerPoint and Word Graphics are unsuitable for printed pictures. Avoid using pixel-oriented software. Scans (TIFF only) should have a resolution of at least 350 dpi (halftone) or 700 to 1100 dpi (line drawings). Please give the data for figures in black and white or submit a Color Work Agreement form. EPS files must be saved with fonts embedded (and with a TIFF preview, if possible).

For scanned images, the scanning resolution at final image size ought to be as follows to ensure good reproduction: line art: >650 dpi; halftones (including gel photographs): >350 dpi; figures containing both halftone and line images: >650 dpi.

Color charges: Authors are advised to pay the full cost for the reproduction of their color artwork. Hence, please note that if there is color artwork in your manuscript when it is accepted for publication, we would require you to complete and return a Color Work Agreement form before your paper can be published. Also, you can email your editor to remove the color fee after acceptance of the paper.

Tips for Writing a Good Quality Science Frontier Research Paper

Techniques for writing a good quality Science Frontier Research paper:

1. Choosing the topic: In most cases, the topic is selected by the interests of the author, but it can also be suggested by the guides. You can have several topics, and then judge which you are most comfortable with. This may be done by asking several questions of yourself, like "Will I be able to carry out a search in this area? Will I find all necessary resources to accomplish the search? Will I be able to find all information in this field area?" If the answer to this type of question is "yes," then you ought to choose that topic. In most cases, you may have to conduct surveys and visit several places. Also, you might have to do a lot of work to find all the rises and falls of the various data on that subject. Sometimes, detailed information plays a vital role, instead of short information. Evaluators are human: The first thing to remember is that evaluators are also human beings. They are not only meant for rejecting a paper. They are here to evaluate your paper. So present your best aspect.

2. Think like evaluators: If you are in confusion or getting demotivated because your paper may not be accepted by the evaluators, then think, and try to evaluate your paper like an evaluator. Try to understand what an evaluator wants in your research paper, and you will automatically have your answer. Make blueprints of paper: The outline is the plan or framework that will help you to arrange your thoughts. It will make your paper logical. But remember that all points of your outline must be related to the topic you have chosen.

3. Ask your guides: If you are having any difficulty with your research, then do not hesitate to share your difficulty with your guide (if you have one). They will surely help you out and resolve your doubts. If you can't clarify what exactly you require for your work, then ask your supervisor to help you with an alternative. He or she might also provide you with a list of essential readings.

4. Use of computer is recommended: As you are doing research in the field of science frontier then this point is quite obvious. Use right software: Always use good quality software packages. If you are not capable of judging good software, then you can lose the quality of your paper unknowingly. There are various programs available to help you which you can get through the internet.

5. Use the internet for help: An excellent start for your paper is using Google. It is a wondrous search engine, where you can have your doubts resolved. You may also read some answers for the frequent question of how to write your research paper or find a model research paper. You can download books from the internet. If you have all the required books, place importance on reading, selecting, and analyzing the specified information. Then sketch out your research paper. Use big pictures: You may use encyclopedias like Wikipedia to get pictures with the best resolution. At Global Journals, you should strictly follow here.



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6. Bookmarks are useful: When you read any book or magazine, you generally use bookmarks, right? It is a good habit which helps to not lose your continuity. You should always use bookmarks while searching on the internet also, which will make your search easier.

7. Revise what you wrote: When you write anything, always read it, summarize it, and then finalize it.

8. Make every effort: Make every effort to mention what you are going to write in your paper. That means always have a good start. Try to mention everything in the introduction—what is the need for a particular research paper. Polish your work with good writing skills and always give an evaluator what he wants. Make backups: When you are going to do any important thing like making a research paper, you should always have backup copies of it either on your computer or on paper. This protects you from losing any portion of your important data.

9. Produce good diagrams of your own: Always try to include good charts or diagrams in your paper to improve quality. Using several unnecessary diagrams will degrade the quality of your paper by creating a hodgepodge. So always try to include diagrams which were made by you to improve the readability of your paper. Use of direct quotes: When you do research relevant to literature, history, or current affairs, then use of quotes becomes essential, but if the study is relevant to science, use of quotes is not preferable.

10. Use proper verb tense: Use proper verb tenses in your paper. Use past tense to present those events that have happened. Use present tense to indicate events that are going on. Use future tense to indicate events that will happen in the future. Use of wrong tenses will confuse the evaluator. Avoid sentences that are incomplete.

11. Pick a good study spot: Always try to pick a spot for your research which is quiet. Not every spot is good for studying.

12. Know what you know: Always try to know what you know by making objectives, otherwise you will be confused and unable to achieve your target.

13. Use good grammar: Always use good grammar and words that will have a positive impact on the evaluator; use of good vocabulary does not mean using tough words which the evaluator has to find in a dictionary. Do not fragment sentences. Eliminate one-word sentences. Do not ever use a big word when a smaller one would suffice.

Verbs have to be in agreement with their subjects. In a research paper, do not start sentences with conjunctions or finish them with prepositions. When writing formally, it is advisable to never split an infinitive because someone will (wrongly) complain. Avoid clichés like a disease. Always shun irritating alliteration. Use language which is simple and straightforward. Put together a neat summary.

14. Arrangement of information: Each section of the main body should start with an opening sentence, and there should be a changeover at the end of the section. Give only valid and powerful arguments for your topic. You may also maintain your arguments with records.

15. Never start at the last minute: Always allow enough time for research work. Leaving everything to the last minute will degrade your paper and spoil your work.

16. Multitasking in research is not good: Doing several things at the same time is a bad habit in the case of research activity. Research is an area where everything has a particular time slot. Divide your research work into parts, and do a particular part in a particular time slot.

17. Never copy others' work: Never copy others' work and give it your name because if the evaluator has seen it anywhere, you will be in trouble. Take proper rest and food: No matter how many hours you spend on your research activity, if you are not taking care of your health, then all your efforts will have been in vain. For quality research, take proper rest and food.

18. Go to seminars: Attend seminars if the topic is relevant to your research area. Utilize all your resources.

19. Refresh your mind after intervals: Try to give your mind a rest by listening to soft music or sleeping in intervals. This will also improve your memory. Acquire colleagues: Always try to acquire colleagues. No matter how sharp you are, if you acquire colleagues, they can give you ideas which will be helpful to your research.

20. Think technically: Always think technically. If anything happens, search for its reasons, benefits, and demerits. Think and then print: When you go to print your paper, check that tables are not split, headings are not detached from their descriptions, and page sequence is maintained.

21. Adding unnecessary information: Do not add unnecessary information like "I have used MS Excel to draw graphs." Irrelevant and inappropriate material is superfluous. Foreign terminology and phrases are not apropos. One should never take a broad view. Analogy is like feathers on a snake. Use words properly, regardless of how others use them. Remove quotations. Puns are for kids, not grunt readers. Never oversimplify: When adding material to your research paper, never go for oversimplification; this will definitely irritate the evaluator. Be specific. Never use rhythmic redundancies. Contractions shouldn't be used in a research paper. Comparisons are as terrible as clichés. Give up ampersands, abbreviations, and so on. Remove commas that are not necessary. Parenthetical words should be between brackets or commas. Understatement is always the best way to put forward earth-shaking thoughts. Give a detailed literary review.

22. Report concluded results: Use concluded results. From raw data, filter the results, and then conclude your studies based on measurements and observations taken. An appropriate number of decimal places should be used. Parenthetical remarks are prohibited here. Proofread carefully at the final stage. At the end, give an outline to your arguments. Spot perspectives of further study of the subject. Justify your conclusion at the bottom sufficiently, which will probably include examples.

23. Upon conclusion: Once you have concluded your research, the next most important step is to present your findings. Presentation is extremely important as it is the definite medium though which your research is going to be in print for the rest of the crowd. Care should be taken to categorize your thoughts well and present them in a logical and neat manner. A good quality research paper format is essential because it serves to highlight your research paper and bring to light all necessary aspects of your research.

Informal Guidelines of Research Paper Writing

Key points to remember:

- Submit all work in its final form.
- Write your paper in the form which is presented in the guidelines using the template.
- Please note the criteria peer reviewers will use for grading the final paper.

Final points:

One purpose of organizing a research paper is to let people interpret your efforts selectively. The journal requires the following sections, submitted in the order listed, with each section starting on a new page:

The introduction: This will be compiled from reference matter and reflect the design processes or outline of basis that directed you to make a study. As you carry out the process of study, the method and process section will be constructed like that. The results segment will show related statistics in nearly sequential order and direct reviewers to similar intellectual paths throughout the data that you gathered to carry out your study.

The discussion section:

This will provide understanding of the data and projections as to the implications of the results. The use of good quality references throughout the paper will give the effort trustworthiness by representing an alertness to prior workings.

Writing a research paper is not an easy job, no matter how trouble-free the actual research or concept. Practice, excellent preparation, and controlled record-keeping are the only means to make straightforward progression.

General style:

Specific editorial column necessities for compliance of a manuscript will always take over from directions in these general guidelines.

To make a paper clear: Adhere to recommended page limits.



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Mistakes to avoid:

- Insertion of a title at the foot of a page with subsequent text on the next page.
- Separating a table, chart, or figure—confine each to a single page.
- Submitting a manuscript with pages out of sequence.
- In every section of your document, use standard writing style, including articles ("a" and "the").
- Keep paying attention to the topic of the paper.
- Use paragraphs to split each significant point (excluding the abstract).
- Align the primary line of each section.
- Present your points in sound order.
- Use present tense to report well-accepted matters.
- Use past tense to describe specific results.
- Do not use familiar wording; don't address the reviewer directly. Don't use slang or superlatives.
- Avoid use of extra pictures—include only those figures essential to presenting results.

Title page:

Choose a revealing title. It should be short and include the name(s) and address(es) of all authors. It should not have acronyms or abbreviations or exceed two printed lines.

Abstract: This summary should be two hundred words or less. It should clearly and briefly explain the key findings reported in the manuscript and must have precise statistics. It should not have acronyms or abbreviations. It should be logical in itself. Do not cite references at this point.

An abstract is a brief, distinct paragraph summary of finished work or work in development. In a minute or less, a reviewer can be taught the foundation behind the study, common approaches to the problem, relevant results, and significant conclusions or new questions.

Write your summary when your paper is completed because how can you write the summary of anything which is not yet written? Wealth of terminology is very essential in abstract. Use comprehensive sentences, and do not sacrifice readability for brevity; you can maintain it succinctly by phrasing sentences so that they provide more than a lone rationale. The author can at this moment go straight to shortening the outcome. Sum up the study with the subsequent elements in any summary. Try to limit the initial two items to no more than one line each.

Reason for writing the article—theory, overall issue, purpose.

- Fundamental goal.
- To-the-point depiction of the research.
- Consequences, including definite statistics—if the consequences are quantitative in nature, account for this; results of any numerical analysis should be reported. Significant conclusions or questions that emerge from the research.

Approach:

- Single section and succinct.
- An outline of the job done is always written in past tense.
- Concentrate on shortening results—limit background information to a verdict or two.
- Exact spelling, clarity of sentences and phrases, and appropriate reporting of quantities (proper units, important statistics) are just as significant in an abstract as they are anywhere else.

Introduction:

The introduction should "introduce" the manuscript. The reviewer should be presented with sufficient background information to be capable of comprehending and calculating the purpose of your study without having to refer to other works. The basis for the study should be offered. Give the most important references, but avoid making a comprehensive appraisal of the topic. Describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will give no attention to your results. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here.

The following approach can create a valuable beginning:

- Explain the value (significance) of the study.
- Defend the model—why did you employ this particular system or method? What is its compensation? Remark upon its appropriateness from an abstract point of view as well as pointing out sensible reasons for using it.
- Present a justification. State your particular theory(-ies) or aim(s), and describe the logic that led you to choose them.
- Briefly explain the study's tentative purpose and how it meets the declared objectives.

Approach:

Use past tense except for when referring to recognized facts. After all, the manuscript will be submitted after the entire job is done. Sort out your thoughts; manufacture one key point for every section. If you make the four points listed above, you will need at least four paragraphs. Present surrounding information only when it is necessary to support a situation. The reviewer does not desire to read everything you know about a topic. Shape the theory specifically—do not take a broad view.

As always, give awareness to spelling, simplicity, and correctness of sentences and phrases.

Procedures (methods and materials):

This part is supposed to be the easiest to carve if you have good skills. A soundly written procedures segment allows a capable scientist to replicate your results. Present precise information about your supplies. The suppliers and clarity of reagents can be helpful bits of information. Present methods in sequential order, but linked methodologies can be grouped as a segment. Be concise when relating the protocols. Attempt to give the least amount of information that would permit another capable scientist to replicate your outcome, but be cautious that vital information is integrated. The use of subheadings is suggested and ought to be synchronized with the results section.

When a technique is used that has been well-described in another section, mention the specific item describing the way, but draw the basic principle while stating the situation. The purpose is to show all particular resources and broad procedures so that another person may use some or all of the methods in one more study or referee the scientific value of your work. It is not to be a step-by-step report of the whole thing you did, nor is a methods section a set of orders.

Materials:

Materials may be reported in part of a section or else they may be recognized along with your measures.

Methods:

- Report the method and not the particulars of each process that engaged the same methodology.
- Describe the method entirely.
- To be succinct, present methods under headings dedicated to specific dealings or groups of measures.
- Simplify—detail how procedures were completed, not how they were performed on a particular day.
- If well-known procedures were used, account for the procedure by name, possibly with a reference, and that's all.

Approach:

It is embarrassing to use vigorous voice when documenting methods without using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result, when writing up the methods, most authors use third person passive voice.

Use standard style in this and every other part of the paper—avoid familiar lists, and use full sentences.

What to keep away from:

- Resources and methods are not a set of information.
- Skip all descriptive information and surroundings—save it for the argument.
- Leave out information that is immaterial to a third party.



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Results:

The principle of a results segment is to present and demonstrate your conclusion. Create this part as entirely objective details of the outcome, and save all understanding for the discussion.

The page length of this segment is set by the sum and types of data to be reported. Use statistics and tables, if suitable, to present consequences most efficiently.

You must clearly differentiate material which would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matters should not be submitted at all except if requested by the instructor.

Content:

- Sum up your conclusions in text and demonstrate them, if suitable, with figures and tables.
- In the manuscript, explain each of your consequences, and point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation of an exacting study.
- Explain results of control experiments and give remarks that are not accessible in a prescribed figure or table, if appropriate.
- Examine your data, then prepare the analyzed (transformed) data in the form of a figure (graph), table, or manuscript.

What to stay away from:

- Do not discuss or infer your outcome, report surrounding information, or try to explain anything.
- Do not include raw data or intermediate calculations in a research manuscript.
- Do not present similar data more than once.
- A manuscript should complement any figures or tables, not duplicate information.
- Never confuse figures with tables—there is a difference.

Approach:

As always, use past tense when you submit your results, and put the whole thing in a reasonable order.

Put figures and tables, appropriately numbered, in order at the end of the report.

If you desire, you may place your figures and tables properly within the text of your results section.

Figures and tables:

If you put figures and tables at the end of some details, make certain that they are visibly distinguished from any attached appendix materials, such as raw facts. Whatever the position, each table must be titled, numbered one after the other, and include a heading. All figures and tables must be divided from the text.

Discussion:

The discussion is expected to be the trickiest segment to write. A lot of papers submitted to the journal are discarded based on problems with the discussion. There is no rule for how long an argument should be.

Position your understanding of the outcome visibly to lead the reviewer through your conclusions, and then finish the paper with a summing up of the implications of the study. The purpose here is to offer an understanding of your results and support all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of results should be fully described.

Infer your data in the conversation in suitable depth. This means that when you clarify an observable fact, you must explain mechanisms that may account for the observation. If your results vary from your prospect, make clear why that may have happened. If your results agree, then explain the theory that the proof supported. It is never suitable to just state that the data approved the prospect, and let it drop at that. Make a decision as to whether each premise is supported or discarded or if you cannot make a conclusion with assurance. Do not just dismiss a study or part of a study as "uncertain."

Research papers are not acknowledged if the work is imperfect. Draw what conclusions you can based upon the results that you have, and take care of the study as a finished work.

- You may propose future guidelines, such as how an experiment might be personalized to accomplish a new idea.
- Give details of all of your remarks as much as possible, focusing on mechanisms.
- Make a decision as to whether the tentative design sufficiently addressed the theory and whether or not it was correctly restricted. Try to present substitute explanations if they are sensible alternatives.
- One piece of research will not counter an overall question, so maintain the large picture in mind. Where do you go next? The best studies unlock new avenues of study. What questions remain?
- Recommendations for detailed papers will offer supplementary suggestions.

Approach:

When you refer to information, differentiate data generated by your own studies from other available information. Present work done by specific persons (including you) in past tense.

Describe generally acknowledged facts and main beliefs in present tense.

The Administration Rules

Administration Rules to Be Strictly Followed before Submitting Your Research Paper to Global Journals Inc.

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Written material: You may discuss this with your guides and key sources. Do not copy anyone else's paper, even if this is only imitation, otherwise it will be rejected on the grounds of plagiarism, which is illegal. Various methods to avoid plagiarism are strictly applied by us to every paper, and, if found guilty, you may be blacklisted, which could affect your career adversely. To guard yourself and others from possible illegal use, please do not permit anyone to use or even read your paper and file.

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Please note that following table is only a Grading of "Paper Compilation" and not on "Performed/Stated Research" whose grading solely depends on Individual Assigned Peer Reviewer and Editorial Board Member. These can be available only on request and after decision of Paper. This report will be the property of Global Journals.

Topics	Grades		
	A-B	**C-D**	**E-F**
Abstract	Clear and concise with appropriate content, Correct format. 200 words or below	Unclear summary and no specific data, Incorrect form Above 200 words	No specific data with ambiguous information Above 250 words
Introduction	Containing all background details with clear goal and appropriate details, flow specification, no grammar and spelling mistake, well organized sentence and paragraph, reference cited	Unclear and confusing data, appropriate format, grammar and spelling errors with unorganized matter	Out of place depth and content, hazy format
Methods and Procedures	Clear and to the point with well arranged paragraph, precision and accuracy of facts and figures, well organized subheads	Difficult to comprehend with embarrassed text, too much explanation but completed	Incorrect and unorganized structure with hazy meaning
Result	Well organized, Clear and specific, Correct units with precision, correct data, well structuring of paragraph, no grammar and spelling mistake	Complete and embarrassed text, difficult to comprehend	Irregular format with wrong facts and figures
Discussion	Well organized, meaningful specification, sound conclusion, logical and concise explanation, highly structured paragraph reference cited	Wordy, unclear conclusion, spurious	Conclusion is not cited, unorganized, difficult to comprehend
References	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring

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