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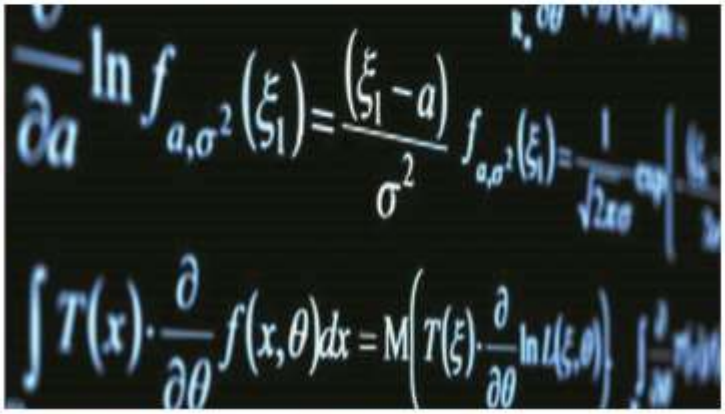

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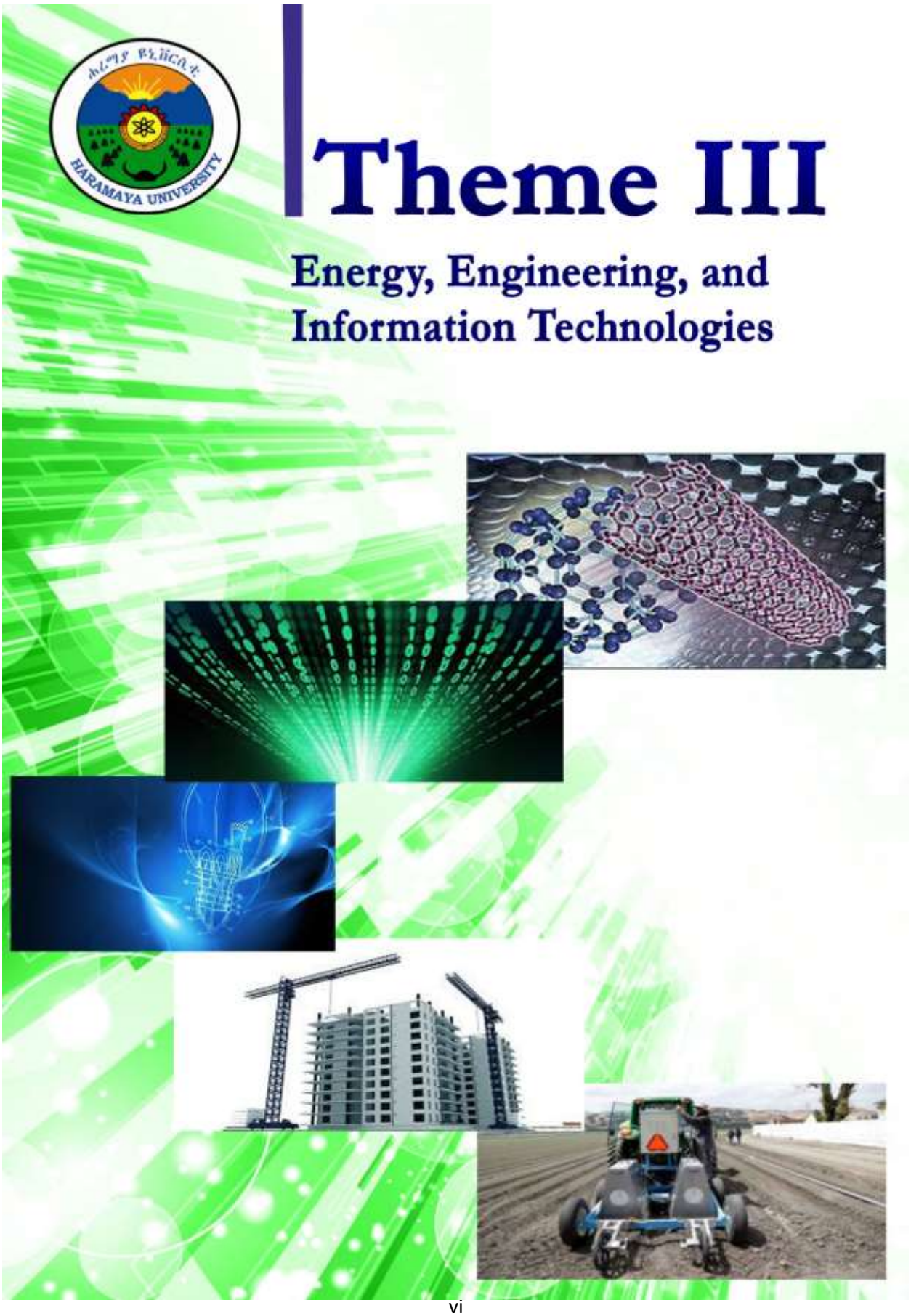
Energy, Engineering, and Information Technologies



1. Estimating the Levels of Microbiological Contamination with Isolation and Drug Resistant Test on Selected Pathogen from Commercial Soft Drinks Purchased from two Eastern Ethiopian Towns

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Abstract: Industrial commercial soft drink products are manufactured and transported to consumers at a distance. The aim of this study was to investigate microbiological load, and to isolate microbial genera in ready-to-drink commercial soft drinks (energy drinks, juices and water). A total of 774 products were randomly sampled and examined for aerobic plate count (APC), *Enterobacteriaceae* count (EBC), total coliform count (TCC) and total yeast and mold count (TMYC), and for contaminate microbial genera. An overall mean of 3.56 log for APC, 3.44 log for EBC, 3.40 log for TCC and 3.42 log for TMYC CFU/ml was observed in the products. An overall 3.45 log for *Staphylococcus* total count (TSC) CFU/ml was observed. Considering five studied risk factors, the mean count ranged from 3.40 log to 3.50 log by both product type and public supply markets and 3.40 log to 3.75 log by producing countries. From total samples, 14 different categories of microbial genera consisting of 9.3% *Staphylococcus*, 4.8% Bacillus, 2.2% Streptococcus, 1.8% Enterobacter, 1.4% Clostridia, 1.2% *Actinomycetes*, 1.0% Yeast, 0.8% Coranybacters, 0.8% Nesseria, 0.6% Micrococcus, 0.3% Campylobacters, 0.3% Listeria, 0.1% Molds and 1.4% unidentified microbes were observed. Of 72 *Staphylococcus*, 44 (5.7%) coagulase negative *Staphylococcus* (CNS) and 28 (3.6%) S. aureus were observed. S. aureus were slightly lower than CNS among all factors. From 72 isolates, 63.9%, 45.8%, 44.4%, 30.6%, 23.6%, 18.0%, 9.7% and 2.8% were found resistant to erythromycin, ampicillin, streptomycin, amoxicillin, cefoxitine, each gentamycin and chloramphenicol, trimethoprim-sulfamethoxazole and ciprofloxacin, respectively. Of the total isolates, 53 (70.8%) consisting 35 (79.5%) of CNS and 18 (64.3%) of S. aureus isolates were develop single to multiples of seven drug resistance. The combination of drug(s) to which CNS showed resistance were not occurred in S. aureus isolates and vice versa. Uncontrolled trading and marketing of ready-to-drink commercial product may have microbial of high public health risk with foreign microbial epidemiology in Ethiopia.

Keywords: Commercial Soft drink; Microbiological load; Microbial genera; Contamination; Public health, Drug resistance

1. Introduction

Commercial soft drinks such as canned or bottled energy drink, juice and water are currently gaining popularity in food industry sectors (Juvonen *et al*., 2011). Food industries are processing produced and transported to consumer under different handling conditions. Typical soft drinks contain water, sweetener, carbon dioxide, acidulants, flavorings colorings, chemical, preservatives (lawful limits), antioxidants, foaming agents (saponins while sugar is used as substituent in others (Kregiel, 2015). According to Juvonen *et al.* (2011) and Sebastia *et al.* (2012), soft drinks processing has altered the potential for spoilage problems. They are generally considered as nutrient poor media that are spoiled by relatively few organisms usually yeasts, and a few acid-tolerant bacteria and fungi. On the other hand, Juvonen *et al.* (2011) and Vaughan *et al.* (2005) suggested risk of warmer weather and inadequate refrigeration for the principal causes of higher levels of contamination, increased diversity and change in microbial flora in the commercial product in warmer areas. Sebastia *et al.* (2012) reported ranges spoilage microbial from home-made tiger-nut beverages in Spain. Juvonen *et al.* (2011) considered some public health hazard microbial as a most likely known threat in the acidic products like juice due to their good acid-tolerance.

Whether produced by commercial industries (Vaughan *et al.,* 2005; Lawlor *et al.,* 2010) or traditional home methods (Sebastia *et al*., 2012; Ashenefi, 2002; Yohannes *et al.,* 2013), non-alcoholic beverages have risk of microbial contamination leading to deterioration with changes of product sensory quality and posing substantial public health risks (Juvonen *et al*., 201; Sebastia *et al*., 2012; Vaughan *et al*., 2005; Ashenefi, 2002; Akond *et al.,* 2009). The presence of spoilage and public health risk microorganisms in food and drinks can be indicated by aerobic plate count (APC), *Enterobacteriaceae* count (EBC), total coli form count (TCC), total staphylococcal count (TSC), and yeast and mold count (TYMC) (Montville *et al.* 2012) and by isolation of the pathogenic agents (Montville *et al.* 2012; Argundi *et al.,* 2010; ICMSF, 1986; Jay *et al*., 2005; Matheson *et al*., 2011). *Staphylococcus* has been reported from carbonated soft-drinks (Akond et al., 2009). It was isolated at rate of 6.14% from various freshly prepared fruit juices (Ahmed et al., 2009) and 5.8% from traditional and commercial dairy products (Rahimi, 2013). The situation leads to development of new antimicrobial agents (Appelbaum, *2006*). The presence of product contamination with staphylococcal can be indicated by total staphylococcal count (TSC) and isolation the agent (Montville et al., 2012). Ashenafi (2002) reported possible risk associated with microbial from traditional beverage of Ethiopia. The subject of this study is industrial processed commercial soft drinks, which are canned, bottled and packed either imported to or produced in Ethiopia. The aim of study was to estimate the levels of microbiological contamination, isolates bacterial genera with antimicrobial susceptibility test on the selected public health pathogenic isolate from commercial soft drinks at different public supply locations in two towns of Eastern Ethiopia.

2. Materials and Methods

2.1. Study Area Location

Study samples were collected from Chiro (9° 05'-9° 08'N, 40° 52'E-40° 87'E) and Dire Dawa (9° 27' – 9° 49'N, 41° 38' – 42° 19'E) towns with an average annual temperature of 20.2 °C and 24.6 °C in eastern part of Ethiopia, respectively.

2.2. Studied Commercial Soft Drinks

The soft drinks studied were juices, energy drink and bottled water packed either in carton, glass bottle, metal can or plastic materials into volume of 125ml to 1000ml. They include non-carbonated, carbonated and fruit juice, often with the addition of organic acid preservatives in most of them. The labeling on the packaging materials (glass battles or metal) of most of fruit juices indicated were pasteurized, hot, aseptic or clean filled.

While some others are carton based packaging pasteurized using ultra-high pressure. Most energy drinks and bottled water are packed in glass and plastic bottles, and are treated using ultra-high heat pasteurization. The products were sampled using randomly sampling from December 2015 to May 2016.

2.3. Sampling

Prior to sampling, variables of study were determined and include product category (juices, energy drink and bottled water), types of packaging material (carton box, glass bottles, metal can and plastic bottles), public supply locations (hotels, open market shops, restaurant, street and supermarkets), source town (Dire Dawa and Chiro towns) and the producing countries. Expire date was also included and the samples were labeled with identification number and transported to Microbiology Laboratory, College of Veterinary Medicine, Haramaya University, on the day of sampling in an ice box at +4^{o}C. Ten milliliters of sample was used for analysis.

2.4. Spoilage Bacteria

Microbial load was estimated using method described by Montville *et al.* (2012). For APC, EBC, TCC and TYMC. Ten ml of sample was diluted in 90 ml of buffered peptone water (BPW) (Merck, Darmstadt, Germany) and was homogenized with Vortex Mixer (Fisher Scientific™). Serial dilutions of 1:10 in sterile NaCl (0.9%) were prepared, and 0.1 ml amounts were plated on Plat Count agar (Oxoid, UK) for APC, and Violet Red Bile Glucose agar (Oxoid Ltd., UK) for EBC, MacConkey agar (Oxoid Ltd, UK) for TCC and Sabouraud Dextrose agar (Oxoid Ltd, UK) for TYMC. All plates were incubated at 30^{o}C for 48 h, but at room temperature (25-27°C) for 5 days, undisturbed, for TYMC> For TSC, again 0.1-ml amounts were plated on Baird-Parker agar (BPAB) (Oxoid, UK). Plates were incubated at 30^{o}C for 48 h. The colonies were enumerated. Detection limit was set according to Montville *et al.* (2012). The data within the detection limit were expressed as colony forming units (CFU) per milliliter and the weighted means were calculated.

2.5. Isolation of Microbial Genera

The initial BPW broth (1:10) served as pre-enrichment and was incubated for 18hrs at 37^{o}C. For bacteria isolation, one loopful was plated on 5% sheep blood supplied Blood agar (Oxoid Ltd., UK) and incubated at 37^{o}C for 18 h. Gram's stain was applied on each of specific colonies. Gram's positive bacteria were categorized into cocci and bacilli. Again the cooci characterized into *Streptococcus* using Gram's morphology and its negative reaction to catalase test by 3% H_2O_2 while the bacilli into *Corynebacterium, Clostridium, Listeria* and *Bacillus* using Grams's morphology, spore staining, anaerobic culture and biochemical tests (Montville *et al.* 2012; Jay *et al.*, 2005, Quinn *et al.,* 2011). Gram's negatives were categorized into *Coccobacilli, Cocci* and *Bacilli*. The cocci was termed as *Neisseria*, the bacilli were further differentiated using lactose utilization test followed by oxidative fermentation test using OF basal medium (Becton, USA) and oxidase test using (Bactident® Oxidase, Merck, Germany) according to Jay *et al.* (2005) procedures. For mold and yeast isolation, similarly one loopful was plated on Sabouraud Dextrose agar (Oxoid, UK) which was prepare by adding 50 mg/liter Chloramphenicol before autoclaving. The plate was then incubated undisturbed at room temperature (25-27^{o}C) for 5 days. With regards to *Staphylococcus* isolation and identification, the initial BPW broth (1:10) served as pre-enrichment and was incubated for 18 h at 37^{o}C. For bacteria isolation, one loopful was plated on Mannitol salt agar (Oxoid, UK) and incubated at 37^{o}C for 18 h. Grams's staining, catalase test using 3% H_2O_2 and coagulase test using rabbit plasma (Montville et al., 2012; Jay et al., 2005) were applied on characteristic isolate to differentiate into coagulase positive and coagulase negative *Staphylococcus*. Control

strains *E. coli* ATCC 25922 for negative and *Staphylococcus aureus* ATCC® 25923™ (USA) for positive were used.

2.6. Antimicrobial Susceptibility Test

Antimicrobial susceptibility test was done only one on all of 72 *Staphylococcus* isolates by the Kirby-Bauer disk diffusion method (Bauer *et al.,* 1966; CLSI, 2012). The tested bacterium was taken from an overnight freshly grown culture and inoculated into 5 ml Brain Heart Infusion Broth (Merck, Germany). The inoculated broth was incubated for 4 h to approximately 10^6 CFU/ml at McFarland 0.5% level of turbidity (CLSI, 2012). With this culture, a bacterial lawn was pre-pared on Mueller Hinton agar (Oxoid, UK). Antimicrobials against (Oxoid, UK) which are frequently used in the study area including amoxicillin (AML μg), ampicillin (AMP μg), chloramphenicol (C 30μg), gentamycin (CN μg), ciprofloxacin (CIP μg), cefoxitine (FOX μg), erythromycin (ET μg), streptomycin (STR μg) and trimethoprim-sulfamethoxazole (SXT 1.25/23.75/μg) were used for test. Result was interpreted using the diameter of zone of bacterial growth inhibition surrounding the disc (CLSI, 2012).

2.7. Data Analysis

Data were analyzed using Excel 2007© (Microsoft Corp., Redmond, WA), Stata Ver.11, SPSS 20 (IBM Corp., Armonk, NY) and WinPepi 11.35 (Abramson JH). TSC was expressed using mean and standard deviation in logarithmic function for load. Using a two tailed unpaired *t* values, the level of significance was set at $P < 0.05$. The isolation, prevalence and drug susceptibility were expressed using percentage. Chi-squire ($\chi 2$) and odds ratio (OR) were calculated for *Staphylococcus* isolates using descriptive statistics. Significance of differences was again considered at 95% confidence interval ($P < 0.05$) for study risk factors.

3. Results

3.1. Microbial Load

Regardless of product category, types of packaging material, public supply location and countries of product origin, the APC, EBC, TCC and TYMC were observed in all products (Table 1). An overall mean of 3.56 log for APC was registered in total sample. The mean APC ranged from 3.42 log in bottled water to 3.71 log in juice drinks. The *t* value reveled mean APC was significantly higher in juices than in others by product category ($P < 0.05$). It was ranged from 3.44 log in plastic bottled to 3.99 log in carton box packed products by packaging materials. The computed *t* value shows, mean APC was high in products packed in carton box than in metal can and glass bottled ($P < 0.05$). But, it was significantly lower in products packed in plastic bottles ($P < 0.05$). The count ranged from 3.41 log in products from hotels to 3.70 log in products from street. The *t* value indicated the mean APC was significantly low in products from hotels than other public supply locations ($P < 0.05$). With regard to counties of product origin, the count ranged from 3.43 log each from Ethiopian and Yemeni to 4.12 log from Portugal's products. The *t* value revealed that the mean APC was higher but similar between products from Portugal and Bangladesh ($P > 0.05$) than in products from others ($P < 0.05$).

An overall mean of 3.44 log for EBC in total of studied commercial soft drinks were observed (Table 1). Mean EBC of 3.40 log in both the energy and bottled water drinks and of 3.48 log in juice products were observed. The *t* value showed significantly higher EBC in juice products than in others ($P < 0.05$). The mean EBC of 3.69 log, 3.42 log, 3.41 log and 3.40 log were observed in product packed in carton box, glass bottles, metal can and plastic bottles respectively in decreasing order. It was ranged from 3.40 log in products from hotels to 3.52 log in products from street. The *t* value shows the mean EBC was higher in products from

street than from other public supply locations ($P < 0.05$). The mean EBC ranged from 3.40 log in products both from Ethiopia and Yemen to 3.73 log in products from Portugal. The *t* value shows mean EBC was higher in products from Bangladesh and Portugal than in those from Ethiopia and Yemen ($P < 0.05$).

Of examined samples, the mean of 3.40 log for TCC was observed. The *t* value showed, high mean 3.41 log for TCC in juices than in energy drink and bottled water ($P < 0.05$). The mean TCC ranged from 3.39 log in metal canned to 3.44 log in carton box canned products. The mean count was similar among products at all public supply location ($P > 0.05$). Considering country of product origin, the mean TCC ranged from 3.40 log in products each from Ethiopia, Thailand, UAE Dubai and Yemen to 3.43 log in those from Bangladesh (Table 1).

An overall mean of 3.42 log for TYMC was caluclated in total of examined samples. Mean TYMC was 3.40 log in energy and bottled water drinks but 3.43 log in juice. The *t* value revealed significantly higher TYMC of 3.43 log in juice drink, 3.53 log in carton canned product , 3.47 log in product from street, and 3.64 log in product from Portugal by product type, packaging material, public supply locations and countries of origin, respectively. But mean TYMC were similar and no significant difference among others within variables of study ($P > 0.05$). All assessed microbial load were found similar in products purchased from both studied towns (Table 1).

Table 1. Microbial load in commercial soft drinks by variables of study determined by Mean ± SD of APC, EBC, TCC and TYMC using a two tailed unpaired *t* test¶..

Variables of study	Total No. of Examined samples	log APC CFU/ml		log EBC CFU/ml		log TCC CFU/ml		log TYMC CFU/ml	
		Mean ± SD	*t*-Value	Mean ± SD	*t*-Value	Mean ± SD	*t*-Value	Mean ± SD	*t*-Value
Product category									
Energy drink	195	3.45±0.15	326.3	3.40±0.01	1.3	3.40±0.01	1.3	3.40±0,03	1.5
Juice drink	373	3.71±0.38	186.4	3.48±0.22	308.4	3.41±0.08	796.4	3.43±0.17	386.3
Bottled water	206	3.42±0.14	338.2	3,40±0.01	1.04	3.40±0.01	1.04	3.40±0.01	1.04
Packaging material									
Carton box	84	3.99±0.37	98.4	3.69±0.32	103.7	3.44±0.16	201.9	3.53±0.30	108.1
Glass bottles	259	3.51±0.27	208.8	3.42±0.12	449.4	3.40±0.04	1.3	3.40±0,07	767.8
Metal can	246	3.57±0.31	179.8	3.41±0.05	991.1	3.39±0.01	5.4	3.41±0.07	724.9
Plastic bottles	185	3.44±0.18	253.7	3.40±0.01	1.8	3.40±0.01	1.8	3.40±0.03	1.5
Public supply location									
Hotel	130	3.41±0.11	346.6	3.40±0.00	-	3.40±0.00	-	3.40±0.00	-
Open Market	152	3.63±0.34	130.9	3.44±0.15	281.8	3.40±0.04	914.4	3.41±0.09	451.8
Restaurants	166	3.56±0.32	140.1	3.42±0.11	415.2	3.41±0.07	662.6	3.40±0.05	872.3
Street	156	3.70±0.40	114.5	3.52±0.27	165.3	3.41±0.09	444.2	3.47±0.23	189.7
Supermarkets	170	3.50±0.23	191.4	3.42±0.09	472.3	3.39±0.01	3.9	3.40±0.08	546.7
Source town									
Dire Dawa town	385	3.55±0.31	225.2	3.43±0.15	462.6	3.40±0.04	1.7	3.42±0.12	537.4
Chiro town	389	3.58±0.33	213.4	3.45±0.17	403.4	3.41±0.07	943.1	3.42±0.12	567.3
Country of Origin									
Bangladesh	45	4.02±0.36	74.8	3.61±0.34	70.4	3.43±0.15	156.7	3.40±0.00	-
Egypt	60	3.64±0.37	76.8	3.46±0.15	173.9	3.14±0.07	383.8	3.40±0.00	-
Ethiopia	317	3.43±0.15	404.2	3.40±0.01	4.2	3.40±0.01	4.2	3.40±0.02	2.5
Portugal	45	4.12±0.28	96.9	3.73±0.29	85.6	3.44±0.15	148.9	3.64±0.37	65.3
Saud Arabia	49	3.65±0.36	70.7	3.46±0.21	111.8	3.41±0.06	394.0	3.43±0.16	147.6
Thailand	120	3.56±0.30	130.3	3.41±0.06	588.6	3.40±0.00	-	3.40±0.06	630.8
UAE Dubai	69	3.54±0.29	100.1	3.40±0.00	-	3.40±0.00	-	3.42±0.12	246.6
Yemen	69	3.43±0.11	552.7	3.41±0.06	488.3	3.40±0.02	1.6	3.40±0.00	-
Total	774	3.56±0.32	309.5	3.44±0.16	607.1	3.40±0.06	1.6	3.42±0.12	780.9

Note:¶APC = aerobic plate count; EBC = Enterobacteriaceae count, TCC = total coli form count, TYMC = yeast and mold count; SD= Standard deviation;; - = because SD is zero, the t value was not computed; UAE = United Arab Emirate.

3.2. Load and Prevalence of *Staphylococcus* Isolates

3.2.1. Load of *Staphylococcus*

All sampled and examined commercial soft drink products were within the utilization periods of shelf life. An overall mean of 3.45 log CFU/ml for TSC was observed (Table 2). The mean TSC ranges from 3.40 log to 3.50 log by product type. The *t* value revealed mean TSC was higher in juices than in energy drinks and It was lowest in bottled water ($P < 0.05$). The mean count raged from 3.40 log to 3.65 log by packaging material, and from 3.40 log to 3.50 log by public supply locations, similar and 3.45 log by source town. The mean count ranged from 3.40 log to 3.75 log by producing countries. The *t* value showed similar and significantly higher mean count in products from Bangladesh (3.59 log) and Portugal (3.75 log) than others ($P < 0.05$).

3.2.2. *Staphylococcus* prevalence

With regards to the prevalence (Table 2), an overall 72 (9.3%) consisting of 44 (5.7%) coagulase negative and 28 (3.6%) coagulase positive *Staphylococcus* were evaluated from total of 774 samples. Significant difference in prevalence among product categories ($P < 0.05$) with *OR* six-fold in juice (13.1%) and *OR* four-fold in energy drinks (9.2%) than in bottled water (2.4%) was recorded. The prevalence was significantly high (21.4%) ($P < 0.05$) and bout *OR* four-fold in carton box packed product than in other types of packaging materials. In comparison to literature the value was equal (26.7%) and some extent high prevalence in product from Bangladesh and Portugal with *OR* five-fold than other countries of product origin ($P < 0.05$). Significant differences in prevalence were observed neither among public supply locations nor between source towns ($p > 0.05$). In all considered risk factors, prevalence of coagulase positive *Staphylococcus* were slightly lower than coagulase negative *Staphylococcus* with exception of the equal (18.6%) in carton box packed product

Table 2. Total *Staphylococcus* count (TSC) and its prevalence in commercial soft drink by studied risk factors.

Studied risk factors	Total No. of Examined samples	log TSC CFU/ml		*Staphylococcus* prevalence						
				S. aureus	*Coagulase Negative*	Total isolate				
		Mean ±SD	*t* Value	No. (%)	No. (%)	No. (%)	χ2	*P-value*	OR	95% OR CI
Product category										
Energy drink	195	3.41±0.09	541.7	8 (4.1)	10 (5.1)	18 (9.2)			3.8	1.4-10.1
Juice drink	373	3.50±0.22	303.1	18 (4.8)	31 (8.3)	49 (13.1)	18.0	0.00	6.1	2.3-19.8
Bottled water	206	3.40±0.02	2.2	2 (1.0)	3 (1.5)	5 (2.4)			1	0.3-3.4
Packaging material										
Carton box	84	3.65±0.30	109.9	9 (10.7)	9 (10.7)	18 (21.4)			3.9	2.06-7.6
Glass bottle	259	3.43±0.12	466.0	6 (2.3)	8 (3.1)	14 (5.4)	19.3	0.0	1	0.49-2.0
Metal can	246	3.45±0.16	333.5	6 (2.4)	17 (6.9)	23 (9.2)			1.7	0.91-3.3
Plastic bottle	185	3.40±0.03	1.4	7 (3.8)	10 (5.4)	17 (9.2)			1.7	0.86-3.4
Public supply location										
Hotel	130	3.40±0.00	-	2 (1.5)	4 (3.1)	6 (4.6)			1	0.33-3.0
Open Market	152	3.47±0.19	228.7	10 (6.6)	9 (5.9)	19 (12.5)			2.7	1.12-6.7
Restaurants	166	3.44±0.15	290.5	5 (3.0)	6 (3.6)	11 (6.6)	8.3	0.08	1.4	0.6-3.8
Street	156	3.50±0.23	190.3	9 (5.8)	10 (6.4)	19 (12.2)			2.6	1.1-6.4
Supermarkets	170	3.44±0.14	308.5	2 (1.2)	15 (8.8)	17 (10.0)			2.1	0.9-5.3
Source town										
Dire Dawa town	385	3.45±0.17	407.5	17 (4.4)	19 (4.9)	36 (9.4)	0.0	0.96	1	0.65-1.6
Chiro town	389	3.45±0.17	401.7	11 (2.8)	25 (6.4)	36 (9.3)			1	0.65-1.6
Country of Origin										
Bangladesh	45	3.59±0.30	79.6	8 (17.8)	4 (8.9)	12 (26.7)			6.2	2.5-15.6
Egypt	60	3.41±0.05	531.01	2 (3.3)	2 (3.3)	4 (6.7)			1.5	0.5-4.4
Ethiopia	317	3.40±0.03	2.3	4 (1.3)	10 (3.2)	14 (4.4)			1	0.5-2.2
Portugal	45	3.75±0.30	83.4	4 (8.9)	8 (17.8)	12 (26.7)	53.7	0.00	6.2	2.5-15.6
Saud Arabia	49	3.54±0.24	103.7	4 (8.2)	6 (12.2)	10 (20.4)			5.5	2.0-14-4
Thailand	120	3.45±0.16	237.3	3 (2.5)	9 (7.5)	12 (10.0)			2.4	0.9-5.8
UAE Dubai	69	3.43±0.14	204.8	2 (2.9)	3 (4.3)	5 (10.9)			1.7	0.5-5.2
Yemen	69	3.40±0.02	1.8	1 (1.4)	2 (2.9)	3 (4.3)			0.9	0.2-3.7
Total	774	3.45±0.45	572.4	28 (3.6)	44 (5.7)	72 (9.3)			1	0.7-1.7

Note:¶ SD= Standard deviation; TFTC = Too Few To Count; - = t value was not computed; CNP = Coagulate positive; CNP = Coagulate Negative

3.3. Overall Microbial Genera Prevalence

From a total of 774 samples (Table 3), 4.9% *Bacillus*, 2.2% *Streptococcus*, 1.8% *Enterobacters*, 1.4% each *Clostridium* and unidentified microbial, 1.2% *Actenomycetes*, 1.0% *Yeast*, 0.8% each *Corynbacters* and *Neisseria*, 0.6% *Micrococcu*s, 0.3% each *Campylobacter* and *Listeria*, and 0.1% *Molds* were observed in descending order of prevalence. All of the current isolates were examined in juices (except *Campylobacter*), in product from street (except molds) and in product from both towns (except molds from Dire Dawa town). Product from Yemen was positive for *Bacillus* (26.1%). *Bacillus* and *Streptococcus* were frequent in studied commercial soft drinks with regardless of product category, types of packaging material, public supply location, study town and the country of product origin. The prevalence of isolates was almost similar in products purchased from both studied towns.

3.4. Microbial Genera within Variables of Studied Commercial Soft Drink

As shown in Table 3, except for *Campylobacter,* juices product was found positive for all of currently isolated microbial genera where *Bacillus* were higher (9.4%). *Bacillus* (1.1% to 8.5%) and *Streptococcus* (0.2% to 2.7%) were observed in product packed by all packaging materials. *Bacillus* was not seen in isolates from Thailand but ranged from 0.6% to 26.1% in products originated from other countries. On the other hand, *Streptococcus* was not watched in products from Portugal and Yemen, but ranged from 0.8% to 6.7% in products from others. The challenges in diagnostic reagent and facilities were not allowed us to identify certain isolates. We categorized them under the "unidentified" groups and were 1.4% in total of samples. They were observed in products from Egypt (6.7%), Ethiopia (1.2%), Portugal (4.4%) and Saud Arabia (2.0%).

Table 3. Bacteria genera, yeast and fungi prevalence in commercial soft drinks by variables of study.

Variables of Study	Total No. of Examined	*Actinomycetes* No. (%)	*Bacillus* No. (%)	*Campylobacter* No. (%)	*Clostridia* No. (%)	*Coranybacter* No. (%)	*Enterobacteriaceae* No. (%)	*Mould* (Fungi) No. (%)	*Listeria* No. (%)	*Micrococcus* No. (%)	*Neisseria* No. (%)	*Streptococcus* No. (%)	Yeast No. (%)	Unidentified No. (%)
Product category														
Energy drink	195	-	1(0.5)	-	1(0.5)	-	-	1(0.5)	-	-	-	1(0.5)	2(1.0)	-
Juice drink	373	9(2.4)	35(9.4)	-	10(2.7)	6(1.6)	17(4.6)	1(0.3)	2(0.5)	5(1.3)	6(1.6)	12(3.2)	6(1.6)	7(1.9)
Bottled water	206	-	2(1.0)	2(1.0)	-	-	-	-	-	-	-	4(1.9)	-	4(1.9)
Packaging material														
Carton box	84	4(4.8)	5(6.0)	-	6(7.1)	-	8(9.5)	-	1(1.2)	-	-	1(1.2)	2(2.14)	2(2.4)
Glass bottle	259	5(1.9)	10(3.9)	-	2(0.8)	6(2.3)	4(1.5)	-	-	5(1.9)	5(1.9)	7(2.7)	-	5(1.9)
Metal can	246	-	21(8.5)	-	3(1.2)	-	5(2.0)	1(0.4)	1(0.4)	-	1(0.4)	5(0.2)	4(1.6)	-
Plastic bottle	185	-	2(1.1)	2(1.1)	-	-	-	1(0.5)	-	-	-	4(2.2)	2(1.1)	4(2.2)
Public supply location														
Hotel	130	-	-	-	-	-	-	-	-	-	1(0.8)	-	-	-
Open Market	152	2(1.3)	11(7.2)	1(0.7)	4(2.6)	2(1.3)	5(3.3)	-	-	2(1.3)	0	5(3.3)	1(0.7)	5(3.3)
Restaurants	166	4(2.4)	10(6.0)	-	2(1.2)	3(1.8)	5(3.0)	1(0.6)	-	2(1.2)	2(1.2)	4(2.4)	3(1.8)	4(2.4)
Street	156	3(1.9)	15(9.6)	1(0.6)	5(3.2)	1(0.6)	6(3.8)	-	2(1.3)	1(0.6)	3(1.9)	7(4.5)	2(1.3)	2(1.3)
Supermarkets	170	-	2(1.2)	-	-	-	1(0.6)	1(0.6)	-	-	1(0.6)	10(5.9)	2(1.2)	-
Source town														
Dire Dawa town	385	4(1.0)	19(4.9)	1(0.3)	5(1.3)	3(0.8)	9(2.3)	-	1(0.3)	3(0.8)	3(0.8)	8(2.1)	5(1.3)	5(1.3)
Chiro town	389	5(1.3)	19(4.9)	1(0.3)	6(1.5)	3(0.8)	8(2.1)	2(0.5)	1(0.3)	2(0.5)	3(0.8)	9(2.3)	3(0.8)	6(1.5)
Country of Origin														
Bangladesh	45	-	-	-	7(15.6)	-	12(26.7)	1(2.2)	-	-	-	3(6.7)	3(6.7)	
Egypt	60	4(6.7)	4(6.7)	-	1(1.7)	1(1.7)	3 (5.0)	-	-	-	-	2(3.3)	-	4(6.7)
Ethiopia	317	-	2(0.6)	2(0.6)	1(0.3)	-	-	1(0.3)	-	-	-	4(1.3)	2(0.6)	4(1.3)
Portugal	45	4(8.9)	5(11.1)	-	2(4.4)	-	-	-	-	-	-	-	-	2(4.4)
Saud Arabia	49	1(2.0)	6(12.2)	-	-	5(10.2)	1(2.0)	-	-	5(10.2)	5(10.2)	5(10.2)	-	1(2.0)
Thailand	120	-	-	-	-	-	1(0.8)	-	1(0.8)	-	1(0.8)	1(0.8)	1(0.8)	-
UAE Dubai*	46	-	3(6.5)	-	-	-	-	-	-	-	-	2(4.3)	2(4.3)	-
Yemen	69	-	18(26.1)	-	-	-	-	-	-	-	-	-	-	-
Total	**774**	**9(1.2)**	**38(4.9)**	**2(0.3)**	**11(1.4)**	**6(0.8)**	**14(1.8)**	**1(0.1)**	**2(0.3)**	**5(0.6)**	**6(0.8)**	**17(2.2)**	**8(1.0)**	**11(1.4)**

Note: * *UAE* = *United Arab Emirate;* - = *not detected*

Table 4. Antimicrobial susceptibility pattern of the isolated *Staphylococcus* from commercial soft drink products in the relative orders of increasing susceptibility to specific drug.

Antimicrobial agents	*CN- Staphylococcus (n = 44)*			*S. aureus (n = 28)*			*Total Staphylococcus (N = 72)*		
	S. No. (%)	I. No. (%)	R. No. (%)	S. No. (%)	I. No. (%)	R. No. (%)	S. No. (%)	I. No. (%)	R. No. (%)
ET	12 (27.3)	4 (9.1)	28 (63.6)	8 (28.6)	2 (7.1)	18 (64.3)	20 (27.8)	6 (8.3)	46 (63.9)
AMP	19 (43.2)	1 (2.3)	24 (54.5)	17 (60.7)	2 (7.1)	9 (32.2)	36 (50.0)	3 (4.2)	33 (45.8)
S	14 (31.8)	4 (9.1)	26 (59.1)	20 (71.4)	2 (7.1)	6 (21.4)	44 (61.1)	6 (8.3)	32 (44.4)
AML	23 (51.1)	5 (13.4)	16 (36.4)	18 (64.3)	4 (14.2)	6 (21.4)	41 (65.9)	9 (12.5)	22 (30.6)
FOX	32 (22.7)	0	12 (27.3)	23 (82.1)	0	5 (17.9)	55 (76.4)	0	17 (23.6)
CN	33 (75.0)	2 (4.5)	9 (20.5)	24 (85.7)	0	4 (14.3)	57 (97.2)	2 (2.8)	13 (18.0)
C	37 (84.1)	0	7 (15.9)	21 (75.0)	1 (4.6)	6 (21.4)	58 (80.6)	1 (1.4)	13 (18.0)
SXT	37 (84.1)	0	7 (15.9)	28 (100)	0	0	65 (90.3)	0	7 (9.7)
CIP	42 (95.5)	0	2 (4.5)	28 (100)	0	0	70 (97.2)	0	2 (2.8)

Note: *CP = Coagulase Positive; CN = Coagulase Negative; CN = Gentamycin; S = Streptomycin; FOX = Cefoxitine; AMP = Ampicillin; C = Chloramphenicol; ET = Erythromycin; SXT = Trimethoprim-sulfamethoxazole; CIP = Ciprofloxacin; AML = Amoxicillin; S = Susceptible; I = Intermediate* R = *Resistant*

3.5. *Staphylococcus* Antimicrobial Susceptibility Pattern

Of 72 *Staphylococcus* isolates 63.9%, 45.8%, 44.4%, 30.6%, 23.6%, 18.0%, 9.7% and 2.8% were showed resistant isolate ET, AMP, STR, AML, FOX, each CN and C, SXT and CIP, respectively in descending orders (Table 4). Similarly, as high as 64% of both *CNP* and *CNS* isolates were resistant to ET. Lowest, 2.8% of *CNS* isolate were resistant to CIP but no resistant *CNP* isolates to SXT and CIP.

Table 5. Distribution of single drug to multiple of seven drugs resistant *Staphylococcus* isolates from purchased commercial soft drink products.

Antimicrobial Resistance pattern	Combination of drugs for resistance pattern	*Staphylococcus*		
		S. aureus No. (%)	CNS No. (%)	Total No. (%)
Single drug	AMP	2 (5.7)	-	
	ET	1 (2.9)	2 (11.1)	5 (9.4)
Two drugs	AML, ET	3 (8.6)	-	
	AMP, ET	2 (5.7)	2 (11.1)	
	C, ET	-	1 (5.5)	12 (22.6)
	CN, ET	-	3 (16.7)	
	ET, FOX	-	1 (5.5)	
Three drug	AML, ET, STR	2 (5.7)	-	
	AMP, AML, ET	1 (2.9)	1 (5.5)	
	AMP, ET, STR	1 (2.9)	2 (11.1)	11 (20.8)
	ET, FOX, STR	4 (11.4)	-	
Four drug	AMP, C, ET, STR	1 (2.9)	1 (5.5)	
	AML, C, ET, FOX	-	2 (11.1)	
	AMP, CN, ET, STR	-	1 (5.5)	
	AML, AMP, FOX STR	1 (2.9)	-	10 (18.9)
	C, ET, FOX, STR	1 (2.9)	-	
	AMP, CN, STR, SXT	3 (8.6)	-	
Five dug	AMP, CN, ET, STR, SXT	2 (5.7)	-	
	AML, AMP, ET, STR, FOX	2 (5.7)	-	
	AMP, CN, ET, STR, SXT,	1 (2.9)	-	8 (15.1)
	AML, AMP, C, E, STR	2 (5.7)	-	
	AMP, C, ET, FOX, STR	1 (2.9)	-	
Six drug	ET, STR, AMP, AML, CN, SXT	1 (2.9)	-	
	ET, STR, AMP, AML, C, CIP	1 (2.9)	-	4 (7.5)
	ET, STR, AMP, AML, C, FOX	-	2 (11.1)	
Seven drug	AMP, AML, C, E, CN, FOX, STR	2 (5.7)	-	
	AML, AMP, C, CIP, ET, FOX, STR	1 (2.9)	-	3 (5.7)
Total		**35 (100)**	**18 (100)**	**53 (100)**

Note: CN = Gentamycin; S = Streptomycin; FOX = Cefoxitine; AMP = Ampicillin; C = Chloramphenicol; ET = Erythromycin; SXT = Trimethoprim-sulfamethoxazole; CIP = Ciprofloxacin; AML = Amoxicillin.

For multidrug resistance profile, 53 (70.8%) of overall tested isolates consisting 35 (79.5%) of *CNS* and 18 (64.3%) of *S. aureus* isolates were develop single to multiples of seven drug resistance. From total resistant isolates, 9.8%, 22.6%, 20.8%, 18.9%, 15.1%, 7.5% and 5.7% were found resistant to one, two, three, four, five, six and seven drugs, respectively. In most of the cases, shown in Table 5, the

combination of drug(s) to which *CNS* showed resistance were not occurred for *CNP* isolates and vice versa. Five and seven drugs resistant isolates were observed in *CNS* isolates but not in *S. aureus* isolates.

4. Discussion

The higher APC in juices, in products packed in carton box and metal and in products from street indicated the spoilage risk associated with aerobic microbial. Some carton based packaging cannot be heated. They are also permeable to oxygen which allows the growth of aerobic spoilage agents (Montville *et al.* 2012; Lawlor *et al.,* 2010; Rahman *et al.*, 2011; Stratford, 2006). The mean 3.5.56 log for APC from this study was lower than the 5.84 log aerobic mesospheric (Sebastia *et al.*, 2012) and 1.14 x 10^4 total viable count (Rahman *et al.*, 2011). The present APC finding in juices drink was similar with 1.8x10^3 CFU/ml total viable bacteria reported from commercial juices in Dhaka City by Rahman *et al.* (2011). Relatively, high count mean of 4.02 log and log 4.12 log for APC, in products from Bangladesh and Portugal were observed, respectively. This indicates possible presence of poor transportation of the products during importing to Ethiopia which prone for multiplication of low level contaminates. Juvonen *et al.* (2011) also suggested warmer temperature promotes growth of spoilage microbial in soft drinks.

EBC are indicators of production technology hygiene and are also indicators of post-process product contamination (Juvonen *et al.*, 2011, ICMSF, 1986). The mean 3.40 log for EBC observed in total samples was similar with 3.9 log (Sebastia *et al.*, 2012) but lower than the 4 log CFU/100 ml (Park and Chen, 2009) reported *Enterobacteriaceae* in soft drinks. High mean count of EBC in products from Bangladesh (3.61 log) and Portugal (3.73 log) were observed. This could be due to multiplication of the agent in products while transportation to Ethiopia.

In addition, TCC are indicator of fecal contamination of the product either during processing and remain undestroyed or at end products (Montville *et al.* 2012). The mean 3.40 log for TCC from this study indicated possible contamination of the products with coliform bacteria. The higher mean count of 3.43 log for TCC in products from Bangladesh were observed. Akond *et al.* (2009) reported different ranges of both total coliform and fecal coliform in carbonated soft drinks from Bangladesh. The *Enterobacters* observed was also reported by Rahman *et al.* (2011).

The present overall 3.42 log within a ranges of 3.40 log to 3.64 log for TYMC. Findings from studied commercial soft drinks were lower than the Rahman *et al.* (2011) reports with as high as 2.3 x 10^2 to 9.0 x 10^6 CFU/ml and 2.2 x 103 to 5.7 x 10^6 CFU/ml total fungal count in fresh and commercial packed juices, respectively. Similarly, high (over 4 log CFU/100 ml) yeast and mold cells were reported in soft drinks (Park and Chen, 2009). Higher mean count of 3.64 log for TYMC in products from Portugal than in others were observed. Sebastia *et al.* (2012) also reported 2.69- 4.47 log for yeast and 3.63-4.47 log for moulds. Relatively, low counts of yeast and molds were observed in the studied bottled water and energy drinks than in juice drinks. This could be due to presence of suitable ingredient for the survival and multiplication of these organisms in juice drinks. These organisms have an ability to attack many foods using their relatively versatile environmental requirements of obligate aerobes, broader acid/alkaline pH range 1.5–8.5 and withstand carbonation levels (Juvonen *et al.*, 2011; Sperber, 2009; Tournas *et al.,* 1998).

Staphylococci are normal inhabitants of the skin and mucous membranes of animals and humans. Pathogenic strains are usually coagulase positive (Mahon and Larsen, 1995). The present mean 3.45 log for TSC in commercial juice product was higher than the 4.9 x 10^2 CFU/ml mean *Staphylococcal* count but lie in the range from 0 to 2.3 x 10^3 CFU/ml (Rahman et al., 2011) from Dhaka City. Maduka *et al.* (2014) also reported 34.15% samples with *S. aureus* count while Aljaloud *et al.* (2016) reported absence *Staphylococcus* in energy drink from Raid –Saud Arabia.

The current overall *Staphylococcal* was high (9.3%). *Staphylococcus auras* were also isolated at 6.14% from various freshly prepared fruit juices (Ahmed et al., 2009), 5.8% from traditional and commercial dairy products (Rahimi, 2013), and indicating significant contamination of the product regardless of studied variables. This could be associated with contamination from human during product processing steps

production and harvesting being remain undestroyed in the process. Sollid *et al.* (2014) revised 9.1%-57.8% human from different countries carrying *S. auras*. Both the count and prevalence in both energy drinks and juice were higher than in bottled water. Presence of high nutrients level for growth and the less microbial hurdles properties of many modern soft drinks were suggested factors for microbial survival and multiplication (ICMSF, 1986; Juvonen et al., 2011). The load as well as prevalence in the carton box packed products was higher than in metal, glass and plastic packed products indicating significance packaging material in risk of microbial contamination and multiplication including *Staphylococcus*. Cutter (2002) also suggested the combination of rigid packaging materials made from metal, glass or plastic which provides heat during product processing as the most effective inactivating microorganisms. Imported products mainly from Bangladesh and Portugal showed with high *Staphylococcal* load and prevalence than others. Akond et al (2009) also indicated the pose substantial public health risks of commercial soft drinks in Bangladesh. This could be due to distance of product under warmer weather and inadequate refrigeration Moreira et al (2001) from country of origin to a destination (Ethiopia). Moreover, presence of illegal trading where the products are not handled under recommended conditions favors microbial multiplication (Stratford, 2006; Park and Chen, 2009, Sollid et al., 2014).

The similar microbial load as well as microbial genera were observed in samples from both studies town which could be due to similar handlings of the product and whether condition of the area with equal risk. Isolation of other various microbial including *Bacillus*, *Streptococcus*, *Clostridium, Actenomycetes*, *Corynbacters*, *Neisseria*, *Micrococcu*s, *Campylobacter* and *Listeria* in different types of studied products revealed the presence of wide ranges of microbial genera in the products. Moreover, the soft drinks have a range of nutritional ingredient supporting growth of diversified microbial. The types of microbial genera observed in this study were similar with reports of Sebastia` *et al.* (2012). Others studies also show presence of *Clostridia* species (Back, 2005; Tribst et al., 2009), 59.1% *Bacillus* and 94.2% *Streeptococcus* (Akond *et al.,* 2009) and *Micrococcus* (Rahman *et al*., 2011; Lateef *et al.,* 2004) in various commercial soft drinks. Unlike others report (Juvonen *et al*., 2011; Akond *et al.,* 2009; Rahman *et al*., 2011; Lateef *et al.,* 2004), *Actinomycetes, Campylobacter, Coranybacter and Neisseria* were observed in this stud. The sources of such microbial contaminants could be during processing production either from raw materials, factory environment, packaging equipment and lack of hygiene. Microbial also multiply further, while handling and distance transporting of the products under un-recommended conditions, becoming product deterioration and consumer health risk. Similar suggestions were provided by (Argudin *et al*., 2010; Matheson *et al*., 2011; Straford, 2006; Park and Chen, 2009).

This study showing an overall 72 isolates resistant to ET (63.9%), AMP (5.8%), STR (44.4%), AML (30.6%), FOX (23.6%), each CN and C (18.0%), and CIP (2.8%) indicated the risk of resistant development of *Staphylococcus* to various dugs. The present 64 % resistance among *S. aureus*, CNS and the total isolates to tetracycline was higher than the 19.0% pooled resistant as well as that of 8.3%, 20.0% and 25.0% from poultry, beef and pork were reported by Pesavento et al. (2007) and 31.7 % *S. aureus* from food handlers (Dagnew *et al.,* 2012). The difference could be due to sources of sample type. The present finding showed resistance of 15.9 % CNS and 0% *S. aureus* with 9.7% pooled resistant isolates to co-trimoxazole were similar with 7.7% from milk (Daka *et al*., 2012) but lower than the 53.6% and 44.7% of *S. aureus* from outpatients and inpatients (Kitara et al., 2011), 26.8% of *S. aureus* isolates from apparently healthy food handler (Dagnew *et al.,* 2012). In the current finding, resistance to gentamycin was 20.5% for CNS but no for *S. aureus* with overall 18.0% in total isolates. Resistant isolates *S. aureus* to this drug was also reported as 9.5% in pooled resistant with 16.7%, 10.0 and 5.0% from poultry, beef and pork were reported by Pesavento et al. (2007). In this finding, multidrug resistance (MDR) among 70.8% of overall isolates consisting 79.5% of *CNS* and 64.3% of *S. aureus* isolates were developed single to multiples of seven drug resistance. Observing MDR of 20.8%, 18.9%, 15.1%, 7.5% and 5.7% to multiple of three, four, five, six and seven drugs, respectively indicated the burdune of importing resisistn isolates with commercial soft drinks into Ethiopia. Rahimi (2013) also reported 95.0% of *S. auras* resistant to one or more of two antimicrobial. On the other hand, Daka *et al.,* (2012) reported 49/78 (62.8%) of *S. aureus*

isolates from milk developing MDR to three and above drug. Pesavento et al. (2007) also reported 30.95% of all isolates were multi drug resistant (resistant at least to three antibiotics).

5. Conclusion and Recommendation

Soft drinks have higher level of nutrients for microbial growth, lower acidity and / or milder carbonation level (Juvonen *et al.,* 2011; ICMSF, 1986). Regardless of lake of laboratory supply, the observation of "unidentified" microbial in products from Egypt, Ethiopia, Portugal and Saud Arabia showed the variation in geographic distribution of agents in respective of product type. Presence of *Staphylococci* particularly the pathogenic one (*S. aureus*) as well as other microbial genera in most of imported products could be due contamination and multiplication of the agent from raw materials, factory environment, and lack of personnel hygiene during process production and transportation under poor handling conditions. New ingredients and changes in climate conditions may result in the appearance of new pathogens and spoilage organisms in the commercial soft drink products. It was also suggested that the microbiological safety and stability of these drinks depend on their formulation including the use of chemical preservatives, carbonation, low pH values and pasteurization. Presence of various microbial genera in most of imported products could be due to presence of many micro-organisms in soft drinks as environmental or raw material contaminants, but relatively few can grow within the acidic and under low oxygen environment. Illegal trading of such products with poor handling conditions will also favor spoilage and contaminate microbial multiplication. Observing drug resistant isolates also showed the high risk for transfer of resistant pathogen with food upon global food trading. Hence, the present finding showed high risk of foreign microbial epidemiology in Ethiopia which needs quality control during importation, handling and public supply of these products in Ethiopia with extensive survey in depth. Data from the study also revealed the need for public awareness creation with possible associated health risk.

Hence, the present finding showed high risk of foreign microbial epidemiology in Ethiopia which needs quality control during importation, handling and public supply of these products. These product handlers and consumers shall be aware of the possible associated risk factors and handle the products according to manufacturer instruction. To the best of our knowledge, this is the first microbial survey of commercial soft drink in Ethiopia indicating the need for extensive survey in depth. Data from this study also revealed the types of spoilage and microbial genera for public awareness creation with possible associated health risk.

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2. Estimation of Early Blight Severity on Tomato Leaf Using Image Processing

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Abstract: In this research work, digital image processing methods and techniques were used to estimate early blight severity of tomato on tomato leaf of detached and live tomato leaves by extracting the area feature. Sixty photo graphs of detached tomato leaf samples from five tomato plants, and 20 photo graphs of live tomato leaf samples from four tomato plants were selected purposively as well as using simple random sampling method. By converting the RGB image to gray scale and to CIELAB color model, Otsu's thresholding algorithm was applied to estimate the disease severity of both the detached and live leaves using MATLAB. The severity levels of the detached leaves were also assessed by two experts visually. In most samples, the two experts scored different values for the same sample leaves. On the other hand, the area under disease progress curve was analyzed; and it was found that the accuracy of the algorithm developed for estimation of disease severity using image technology was 96.6%. The result revealed that the disease severity of detached tomato leaves increased progressively with time, and so did the live leaves.

Keywords: Alternaria solani; CIELAB; Disease severity; Early blight; Otsu's thresholding

1. Introduction

Tomato (*Solanum esculentum* Mill.) is originated from South American Andes area. It was first taken to Europe by Spanish conquistadors in the 16th century and from there it was introduced to southern and eastern Asia, Africa, and the Middle East and throughout the world (Pursegrove, 1968; Naika *et al*., 2005). In Ethiopia, there are no local cultivars of tomato evolved or been developed. Hence all varieties grown are exotic introduced from abroad (Yayeh, 1989). Currently it grows in many parts of the country (Inga *et al*., 2006); on large scale under irrigation at Merti, upper Awash agro industry enterprise, Melkassa, Koka, Zuwayi, Wondo - Genet, Guder, Bako and also other areas (Shimeles, 2000). The national average of tomato fruit yield in Ethiopia is often low (12.5 t ha^{-1}) compared even to the neighboring African countries, like Kenya (16.4 t ha^{-1}) (FAO, 2004). The current productivity under the farmers' conditions in Ethiopia is 9.0 t ha^{-1}, whereas yield up to 40.0 t ha^{-1} is recorded on research plots. Farmers get lower yield mainly due to diseases, pests and sub-optimal fertilization (Tesfaye, 2008).

However, tomato plants are susceptible to several fungi, bacteria and viruses. Fungi and bacteria cause fruit, stem or root diseases. In most practices, visual observation method is generally used to estimate disease that influences both quality and crop yields. Commonly fungicides, like mancozeb, ridomil MZ 63.5%, maneb, mancolaxyl 72% WP are used to manage diseases in tomato production. However, excessive use of pesticide for plant disease treatment leaves behind toxic residues on agricultural products and is also a major contributor to ground water contamination (Patil *et al.,* 2011). In this work, mainly early blight of tomato (EBT) and leaf spot diseases, primarily foliage diseases, which could affect leaves, stems and fruits of tomatoes, were considered.

Early blight (EB), caused by the fungus *Alternaria solani* Sorauer, is the major disease of tomato (*Solanum lycopersicum* Mill*)*. The disease in severe cases can lead to complete defoliation and is most damaging on tomato in regions with heavy dew, rainfall, high humidity, and fairly high temperatures (24-29 °C). Generally, *A. solani* has the capability to grow over a wide range of temperatures, i.e. 4 – 36 °C. Epidemics can also take place in semi-arid climates where frequent and prolonged nocturnal dews occur. Early blight causes considerable yield loss to the tomato crop, especially in northern plains and peninsular parts of India. It is increasingly becoming a limiting factor for successful cultivation of tomato in these regions (Sherf and MacNab, 1986).

According to Bocka *et al.* (2010), reliable, precise and accurate estimates of disease severity are important for predicting yield loss, monitoring and forecasting epidemics. Knowledge of disease severity is particularly important to decision makers not only in disease management, for example, applying pesticides to manage disease epidemics, but also for understanding fundamental processes in biology, including co-evolution and plant disease epidemiology. Therefore, proper disease management measures of EBT by applying proportioned fungicides must be undertaken so that crop yield losses may be minimized and excessive application of fungicides may be avoided. However, information on use of image processing to automatically estimate disease severities is lacking in Ethiopia. To this effect, the conventional method through use of visual estimation is employed in disease severity assessment.

Objective, reliable and accurate assessment of disease is necessary for screening and selection to develop new cultivars to quantify and model the development of epidemics in space and time, for the analysis of factors that affect disease development, as a basis of yield loss prediction, in evaluating the relative efficiency of a management tool, stick as a fungicidal spray, and for the definition of threshold levels for management programs, among others (Kranz, 1988). Techniques used for disease assessment should be easy to use, allow rapid estimation, be applicable over a range of conditions, and foremost, be accurate and reproducible. Disease incidence, which is the frequency of diseased tints, such as stems or leaves, is relatively easy to measure objectively using visual assessments. Disease severity, which is the amount or proportion of diseased plant tissue, is much harder to quantify objectively. The most commonly used technique for disease severity assessment on plant organs, such as leaves, employs pictorial keys illustrating progressive increases in disease severity (James, 1971). An operator estimates the proportion or the percentage of diseased tissue on a leaf by comparing it with pictorial keys. While these keys provide an estimate of the level of severity, they are subject to the operator biases.

According to FAO (2013), pesticides are very dangerous to both the people who are applying the pesticides and to those that are living or playing near the fields where pesticides are used or applied. Pesticides can kill aquatic animals, beneficial predators and parasites, domestic and wild animals, and other beneficial organisms, such as insect pollinators. Even the very selective insecticides cause problems for the growth of shrimp and prawns, and there is no "safe use of agricultural pesticides, including fungicides". The remedy is to avoid their use and reduce exposure when applied.

The naked eye detection of plant diseases and using visual estimation of their severities is not satisfactory; it takes time for large farms, and hence expensive. Using technological support, automated detection and measurement of disease severity on vegetable crops is very important to understand the extent of the disease and the amount of fungicides needed for use. This study was carried out to develop an appropriate algorithm-routine that could measure severity of early blight on tomato leaf using image processing. Estimation of the severity level enables to optimize the volume of fungicide to be sprayed for disease management. This is because scientific way of controlling EBT stems from the triangulation of three procedures; these are detection, estimation of severity level and optimizing volume of fungicide to be sprayed.

2. Methodology

Description of the Study Area

The study was carried out in the glasshouse at "Raree" research station of Haramaya University. Haramaya University (HU) is located at 9° 26'N latitude, 42°3'E longitude in East Hararghe Zone, Oromia Regional State, Ethiopia. The altitude in the campus varies from 1980 to 2000 meters above sea level (m.a.s.l.). The mean annual precipitation is 780 mm, and the mean annual maximum and minimum temperatures are 23.4 and 8.25 °C (Paulos and Tadele, 2005).

Experimental Materials

The tomato seed, variety money maker obtained from HU, was planted in the glasshouse at Haramaya University. In performing the computational part of the research, 80 samples of early blight-infected tomato leaves, plastic tray, pots, agar, potato-dextrose, white paper, microscope, digital camera and MATLAB software were the materials used.

Experimental Design and Sampling

Based on the occurrence of early blight of tomato leaf, five infected tomato plants from five pots were selected purposively through observation grown at Haramaya University glass house. Even though the leaves at the bottom of the tomato plants were more susceptible, the sampling method included the three sections (top, middle, and bottom) to avoid singularity of fungal incidence. Thus, one diseased leaf from the bottom, middle and top of each plant was taken by simple random sampling method (Sahu *et al.*, 2013). Therefore, fifteen diagnosed images of tomato detached leaves (DLs) infected by EBT (in each week) were drawn from the five pots. This cycle was continued for four consecutive weeks. In addition to this, the images of four live leaves (LLs) were taken from four tomato plants in the similar way five times at three days interval to analyze and quantify the pattern of disease severity on LLs.

Experimental Procedures

Raising tomato seedlings in plastic tray

Seeds of tomato were sown in plastic trays containing soil with 1:2:3 proportions of sand, compost and clay, respectively, and were kept in the glass-house. The trays had been watered as deemed necessary.

Transplanting Tomato Seedlings

Three weeks old seedlings of tomato were transplanted into pots. One tomato seedling was transplanted per pot (20 cm in diameter). Fertilizer at a rate of 200 kg ha^{-1} DAP was broadcasted at transplanting and 100 kg ha^{-1} urea was side-dressed at early flowering stage (Lemma, 2002).

Isolation of causal pathogen and inoculum preparation

Five fungal isolates were obtained from different naturally-infected tomato leaves showing blight symptoms and identified as *Alternaria solani*, based on the colony cultural and morphological characteristics under the microscope. These leaves were collected from HU glasshouse (Raree). The samples were taken in paper bags to Plant Pathology Laboratory of School of Plant Sciences at HU. The suspected etiologic agent (*A. solani*) of early leaf blight was observed under microscope for detection and potato dextrose agar (PDA) and water agar (WA) were used to isolate and maintain *A. solani* cultures. *A. solani* infected-tomato leaf was thoroughly washed with distilled water and the surface was disinfected with 10% sodium hypochlorite (NaOCl) for one minute and washed with distilled water. After disinfection, five pieces of diseased leaves and petioles were cut with a sterile scalpel and were cultured on the culture medium, i.e. potato dextrose agar (PDA), which was prepared in the Laboratory, in Petri dishes for conidial development.

The PDA was prepared from 200 g of fresh potato, 15 g agar and 20 g D-glucose in one liter of water. Then the culture was incubated at 25 ^{o}C for seven days. The conidia were collected from all Petri dishes and mixed together uniformly in sterilized distilled water to get conidial suspension. The spores were washed from 10 days old culture, and Tween 20 was added to the spore suspension to evenly disperse the conidia and to avoid aggregation before spraying. The inoculum conidia were counted with hemacytometer to adjust the concentration to 10^{-6} spores/ml. The conidial suspension was put at 11 to 12 ^{o}C in the dark for 90 to 100 minutes before inoculation (Nelson, 2006). The spore suspension was sprayed with atomizer directly on the leaves by hand, and thereafter the tomato seedlings were covered with plastic sheet for 48 hours to maintain high humidity.

Disease Detection and Measurement

Three-week old seedlings of tomato plants were transplanted. Two-weeks after transplanting, pathogen inoculation was made, and the occurrence of early blight of tomato was started one week after the inoculation. That is, evaluation of disease severity was started four weeks after transplanting. The assessment was undertaken every eight days and a total of four records (DLs) were taken for every plot; the corresponding images of the four live leaves taken every three days. The disease was evaluated on each sample leaf. The estimation of leaves damaged by early blight was carried out by image processing techniques and expert scoring (visual assessment) method for the detached leaves (DLs), whereas the disease severity evaluation of the live leaves (LLs) was made by image processing only. The result obtained from image processing technique was put in parallel with visual assessment result (expert scoring) for DLs, which was done on the basis of the five scales (0-4) of Horsfall and Heuberger reported by Sanjay and Shrinkant (2011) with little modification. The scale was used to estimate percent leaf area diseased (PLAD) visually. Each scale was assigned a specific PLAD range for each disease as indicated by lesion size, intensity and distribution on an individual. The description of the scale for visual assessment is given in (Table 1).

Table 1. The scales for assessment of tomato leaves damaged by EB infection.

Rating	Leaf infections (Detached leaf assay)	Severity index
0	0%	no symptoms
1	0 to 25%	low
2	26 to 50%	Medium
3	51 to 75%	Strong
4	over 75%	Severe

Source: Sanjay and Shrinkant (2011).

Disease Severity Estimation using Imaging

The task of image processing and segmentation was based on the following steps and hereunder the methods in data collection and how this study was accomplished are described.

Image acquisition

A sample of tomato leaf infected by EBT was captured using digital camera with resolution of 16 megapixel and focal length of F5.6. White background and equal distance, angle and illumination were maintained to protect error emerging from the manual work and setup. Camera was held firmly by its holder to minimize noise and blurring due to motion of camera. The diseased leaf was zoomed in/out and placed flat on a white background, to ensure that the pictures taken contain only the leaf and white background. The entire image was stored in JPEG (JPG) format. After images captured carefully and

stored in individual folder with their names, image enhancement and noise analyzing methods were performed for further image processing steps.

Image processing and enhancement

Image was pre-processed and treated using various techniques, such as segmentation, thresholding, filtering, morphological operations (area extraction), and edge detection as follows. Image was enhanced using a computer to bring out detail that was hidden in an image, or to increase the contrast in low contrast image. Image enhancement produced an output image that subjectively looked better than the original image by changing the pixel's intensity of the input image. Generally, image enhancement enlarges the intensity difference among objects and background. In this study, the above image enhancement techniques were used.

Image segmentation

Image segmentation means partitioning or grouping regions, which have similarity according to predefined similarity criteria and adjacency spatial relationships between pixels. In this study, k-means clustering and threshold techniques were used for segmentation purpose and implemented to obtain total leaf pixels and diseased leaf pixel areas by avoiding the defoliation.

Image area extraction

A feature is a significant piece of information extracted from an image which provides more detailed understanding for about the image. Image feature extraction means transforming an input image data into the set of representative features or image characteristics, which will most meaningfully represent the information that is important for analysis. Image features are of major importance in the isolation of regions of common property within an image and subsequent identification or labeling of such regions. Morphological feature (area) was considered for the disease severity estimation of infected-tomato leaves in this thesis work.

Area (A):- The number of pixels inside the region of the diseased tomato leaf, including the boundary region. It is measured by counting the number of pixels.

$$A = \sum_i \sum_j O(i, j)$$

(1)

Where A is area and O(i, j) represents the object pixels in image.

Image color transformation

To compute the lesion area using a MATLAB algorithm, the image in RGB color model was converted into CIELAB color model. The CIELAB system is a device independent, which is defined by the CIE to classify color according to the human vision. In CIELAB color model, 'L' describes color brightness; 'A' describes the color ranging from green to red; 'B' describes the color ranging from blue to yellow. Conversion Formula for LAB color model is given by the equations 2a, 2b and 2c presented below (Iuo and Zohu, 2009; Chaudhary *et al.*, 2012).

$$L = 0.21226R + 0.7152G + 0.0722B$$

(2a)

$$A = 1.4749(0.2213R - 0.3390G + 0.1177B) + 128$$

(2b)

$$B = 0.6245(0.1949R + 0.6057G - 0.8006B) + 128$$

(2c)

The lesion area was obtained by performing Otsu thresholding method on A-channel of the CIELAB color model. This was done by avoiding defoliation using A-channel of the CIELAB color model by developing the appropriate MATLAB algorithm. A-channel is selected because it is easy for human perception. The other advantage for using CIELAB color model is that the leaf veins are not mistaken as or with the damage. The A-channel is thresholded using Otsu's thresholding method (Otsu, 1979) to segment the damaged and normal parts of the leaves.

Disease severity

Severity (S) is the proportion of percentage diseased tissue to the total leaf area sampled. In this paper, the severity of the leaf damage was estimated by calculating the percentage of the damaged pixels statistic to the normal real leaf pixels distribution. According to James and Teng (1979), severity is the area of plant tissue affected by disease and is expressed as a percentage or proportion as:

$$S = \left(\frac{A_{af}}{A}\right)100 \quad (3)$$

Where, S= disease severity, A= total leaf area and A_{af} = area of plant leaf affected by the disease.

In the digital image, every pixel represents the same size and the area is calculated by counting the number of pixels in the image, so 'S' can be obtained by counting and finding the ratio of pixels of lesion leaf area to total area in the binary image. S may also be expressed as

$$S = \frac{\sum p_d}{\sum p_l} \quad (4)$$

Where: S = Severity extent, p_d = total boundary pixel in disease area and p_l = total boundary pixel of leaf.

Area under disease progression curve

In this study, the AUDPC was calculated based on the disease severity-time graph (section 3.4) of the actual data. The formula for AUDPC was used for manual calculation (equation 5) and the MATLAB's trapezoidal analysis rule was also applied on the raw data obtained from image analysis using MATLAB software and visual assessment by two experts.

$$AUDPC = \sum_{i=0}^{n}\left(\left(\frac{x_{(i+1)}+x_i}{2}\right)\left(t_{(i+1)}-t_i\right)\right) \quad (5)$$

Where: x_i = average foliar severity per plot at the ith observation; t_i = time point of the top rating after first rating in eight-day increments at the ith observation; n = total number of observation times.

Sample image analysis

The image data collected by using digital camera were loaded to a laptop computer for further analyses. The technique based on MATLAB (version R2013a) was used for image processing to detect and estimate the severity level for live and detached leaf assays. The codes were written in MATLAB. The image processing steps done are summarized and illustrated in (Figure 1).

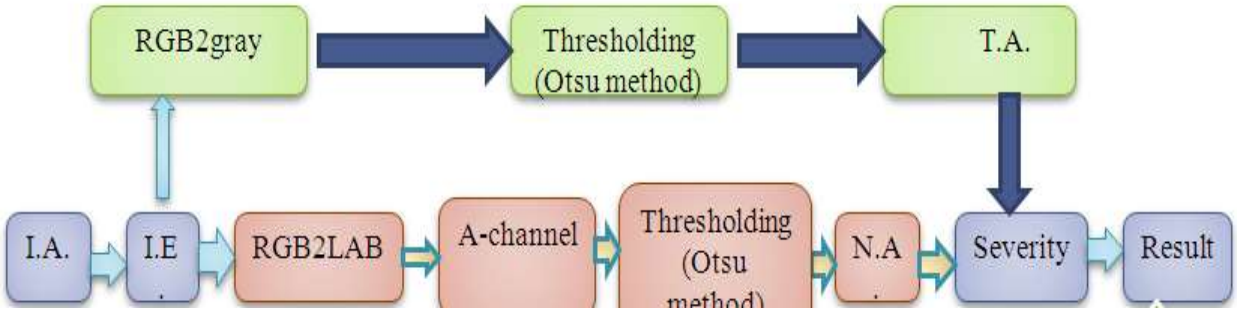


Figure 1. Framework of digital image processing in the analysis of EBT.

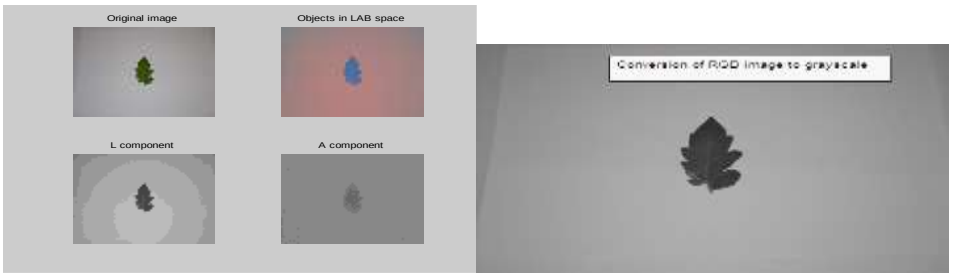
3. Results and Discussion

Result of Image Area Extraction

A two phase color conversion was made (Figure 2); one from RGB into grayscale (Figure 2b) and the other from RGB to LAB (Figure 2a) to extract the area. The total area was determined by converting the RGB image into grayscale (Figure 3a). Moreover, the RGB image was transformed into the LAB color model and Otsu's thresholding was made on the A-channel of the color model to evaluate area of the normal part of the leaf (Figure 3b). The area of the sample leaves were extracted using MATLAB and the values are tabulated in (Table 2) for DLs and (Table 3) for LLs. DL and LL stand for detached and live tomato leaves, respectively, for the first round of sampling. Similarly, the other leaves' areas were extracted in the same way and their area feature results were used to estimate the disease severity.

Experimental result analysis for estimation of disease severity

The result showed that the MATLAB algorithm developed enabled to estimate the disease severity with a great accuracy (96.6%). The average disease severity values for all sixty detached samples and twenty live leaves were estimated. The results are summarized in Table 4 for DLs and Table 5 for LLs. It was observed that the severity level for DLs fluctuated from week two to week three, but for LLs the severity level increases without any decrement for the data collection season.



(a) RGB to LAB color conversion (b) RGB to gray color conversion

Figure 2. The image color transformation result

The overall result revealed that the disease severity of DLs of tomato increased progressively with time (Figure 3) and so did the LLs (Figure 4). The disease severity versus time graphs for DL2 (Figure 4) and LL2 (Figure 5) were sketched, and a cubic spline curve fitting was performed. The graph shows that the disease severity for both leaves increased progressively during the data collection season. Thus, it may be

concluded that the parameters severity and time were positively correlated to each other, and they described the data analysis procedures followed effectively.

Table 2. Area extracted from DLs during the first round (two weeks after inoculation).

P.no.	PLS	Parameters (Round one)			
	(R_1)	TA	NA	IA	IF
P1	1	8023	7315	708	0.0882
	2	5167	5055	112	0.0217
	3	4117	4052	65	0.0158
P2	1	4188	3992	196	0.0468
	2	5034	3817	1217	0.2420
	3	4666	4543	123	0.0264
P3	1	4007	3901	106	0.0265
	2	2572	2437	135	0.0525
	3	3012	2169	843	0.2800
P4	1	4071	4044	27	0.00663
	2	4406	4075	331	0.0751
	3	2404	2328	76	0.0316
P5	1	4476	4344	132	0.0295
	2	3706	3530	176	0.0475
	3	9815	7409	2406	0.2450

P = Tomato plant, P.no. = Tomato Plant number from which the sample leaf was drawn, PLS = Position (section) of the leaf sample, and the numbers 1, 2, and 3 represent the top, middle and bottom sections of the tomato plant, respectively, TA= Total area of the leaf, NA = normal area (area of the normal part of the leaf sample), and IA= Infected area (area of the infected part of the leaf sample), IF=Infected fraction, R_1= Round one.

Table 3. Area extracted from LLs during the first round (two weeks after inoculation).

LL (R1)	Leaf Area			
	TA	NA	IA	IF
LL1	32817	31643	1174	0.0358
LL2	22504	21006	1498	0.0666
LL3	49304	48649	655	0.0133
LL4	30110	29478	632	0.0210

R_1= Round one.

(a) Extraction of total area, and (b) Extraction of normal area.

Figure 3. Extraction of area using image technique:

Table .4. Disease severity value for the four rounds (DLs).

	Severity (%)-Imaging				Severity (%)-Experts			
	R1	R2	R3	R4	R1	R2	R3	R4
DL1	4.19	6.86	26.50	44.40	8.33	6.33	27.20	34.20
DL2	10.51	19.40	32.80	38.10	13.70	21.20	23.50	42.50
DL3	12.00	21.60	17.60	40.00	7.83	13.70	25.80	50.00
DL4	3.78	13.10	8.38	31.00	4.83	15.00	12.70	32.50
DL5	10.70	21.40	15.70	33.90	14.00	20.30	18.80	39.50

Table 5. Disease severity value for the four rounds (LLs).

	Severity (%)				
	R1	R2	R3	R4	R5
LL1	3.58	5.93	6.47	10.6	61.5
LL2	6.66	20.10	46.80	60.1	66.1
LL3	1.33	2.68	2.86	3.56	5.97
LL4	2.10	4.70	36.40	37.1	52.2

Calculating area under disease progression curve and its interpretation

It is often helpful to plot the percentage of leaf area infected versus the evaluation date to get a better idea of how cultivars or varieties perform in the experiment (Figure 6). The calculation of area under disease progression curve (AUDPC) from disease severity-time graph was performed based on the data set obtained from imaging techniques and experts results; the results are complied and tabulated for DLs by imaging and experts' in Tables 6, and for LLs in Tables 7.

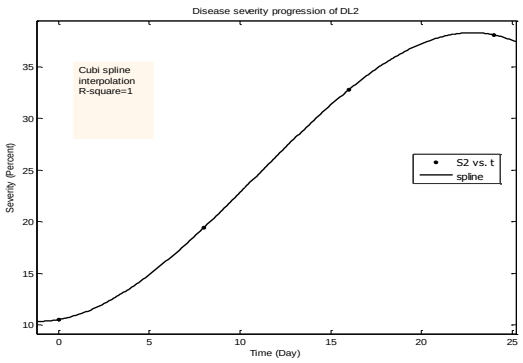


Figure 4. The progression of DLs severity with time of image technique.

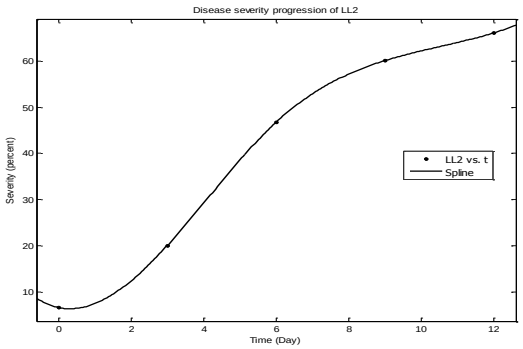


Figure 5. The progression of LLs severity with time of image technique

The result was obtained by manual calculation (A_1) and the MATLAB trapezoidal rules (A_2). The relative error between experts' and imaging result (Δd) in evaluating AUDPC from severity-time curve using trapezoidal rule (3.4%) was not significant as determined using equation (6). The accuracy of the image processing algorithm developed is found to be 96.6%. This shows that the accuracy of the algorithm was good and in line with the work reported by Saranya *et al.* (2014).

$$\Delta d = \left(1 - \frac{AA2}{AA3}\right)100$$

(6)

Where, AA_2 = average value of A_2, and AA_3 = average value of A_3 (Table 7). The AUDPC was also calculated, from the image data, manually (Figure 7), and the result was similar to the MATLAB's result of trapezoidal rule (Table 5) and manual calculation (Figure 5):

h_1=10.7%, h_2=21.4%, h_3=15.7%, h_4=33.9%

t_1=8-0=8days, t_2=16-8=8days, t_3=24-16=8days

Area of a trapezoid (a) is determined as (Spiengel *et al.*, 2009)

$$a = \frac{1}{2}h(b_1 + b_2)$$

(7)

Where, h is height of the trapezoid, b_1 and b_2 are bases of the trapezoid. Putting the above values in equation (7), the following results are obtained for the area of each trapezoidal region (Figure 5).

$$a_1 = \frac{1}{2}t_1(h_1 + h_2) = \frac{1}{2}(8)(10.7 + 21.4) = 128.4\%$$ -days

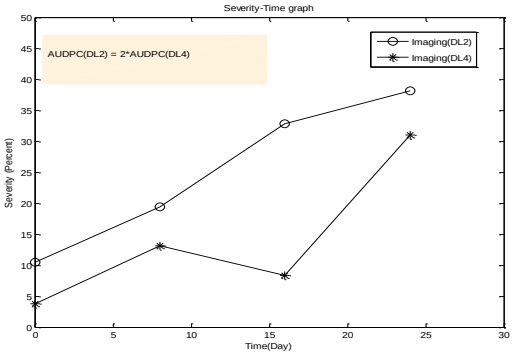


Figure 6. The disease severity-time curve of DL2 and DL4 using actual data.

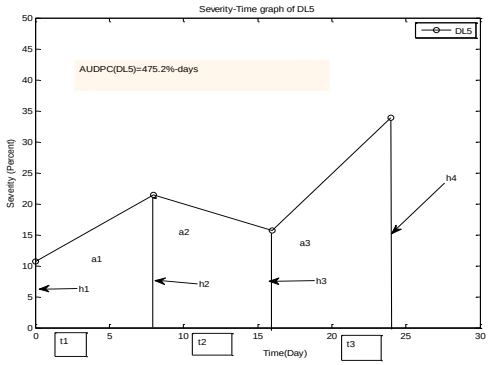


Figure 7. The disease severity–time graph of DL5.

Following a similar procedure, the values of a_2 and a_3 were obtained as 148.4%-days and 198.4%-days, respectively. The total area under the disease progress curve of DL5 was AUDPC (DL5) = $a_1+a_2+a_3$ = 475.20%-days. This result was in agreement with the MATLAB's result obtained above (Table 7). The AUDPC (310.96%-days and 612.04%-days) value through column 3 (Imaging result), rows 6 and 4, showed that the disease incidence was the lightest on tomato plant DL4, while it was the most severe on tomato plant DL2, respectively, which was approximately equal to twice the AUDPC of DL4 during the data collection (Table 7). In spite of the existing little difference between the experts and imaging results, the percent average difference of the two approaches was not significantly different at $P<0.05$ (one-way ANOVA). No difference was observed in evaluating the AUDPC by manual calculation as well as MATLAB except the time elapsed in manual analysis (Table 6, values of A_1 and A_2).

Table 6. Result of AUDPC from LLs

	AUDPC during each interval				
L.S.	a_1(%-days)	a_2(%-days)	a_3(%-days)	a_4(%-days)	Total (%-days)
LL1	14.265	18.600	25.605	108.150	166.62
LL2	40.140	100.350	160.350	189.300	490.14
LL3	6.015	8.310	9.630	14.295	38.25
LL4	10.200	61.650	110.250	133.950	316.05
Average	17.66	47.23	76.46	111.42	252.77

L.S.= Leaf sample

The variables a_1, a_2, a_3, and a_4 represent the AUDPC values for the consecutive four time intervals.

Table 7. Result of AUDPC from DLs (Imaging and experts)

	AUDPC-values		
	Area of imaging data		Area of expert data
L.S	A_1(%-days)	A_2(%-days)	A_3(%-days)
DL1	461.24	461.24	438.36
DL2	612.04	612.04	582.40
DL3	521.60	521.60	547.32
DL4	310.96	310.96	370.92
DL5	475.20	475.20	526.80
Average	476.21	476.21	493.16

L.S= the leaf sample, A1 and A2 are area from the imaging data by manual calculation and MATLAB's trapezoidal rule, respectively, A3= area from the expert data (MATLAB). Since the unit of s is percent (%) and that of t is day, the unit of A (A_1, A_2, A_3), (i.e, area under severity-time curve) is %-days.

Similar procedures were followed to calculate the area under s-t curve for live leaves and the result is presented in Table 6. The research finding revealed that the AUDPC increased with time (Table 6) and the AUDPC (490.14%-days) value was the most severe on tomato plant LL2 but the AUDPC (38.25%-days) value was the lightest on tomato plant LL3. This generated data showed that the disease on LL2 was approximately 13 times more than that of LL3 during the data collection time. Plotting the percentage of leaf area infected with the evaluation period gave a better idea whether the disease incidence was light or severe during the test period (Figure 8). Illustration below showed that the accumulation of daily percent infection values (AUDPC) on tomato plant LL2 increased with increase in time. The overall AUDPC result, as analyzed above from s-t curves of DLs and LLs, discloses that the disease severity on each tomato leaf during the test period increased progressively; this reassures that the disease severity increased accordingly.

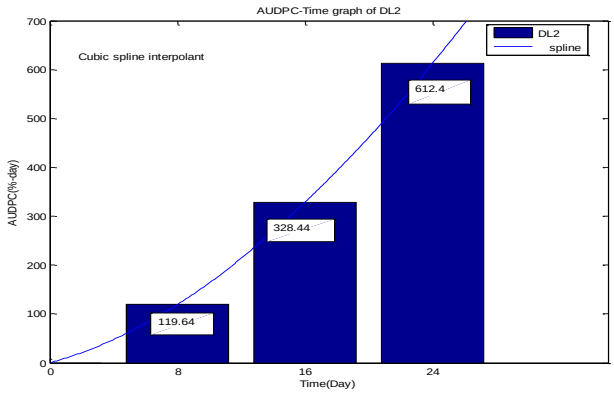


Figure 8. The AUDPC pattern on DL2 with time.

4. Conclusion and Recommendations

4.1 Conclusion

Detection of EBT and estimation of disease severity using DIP by developing appropriate algorithm-routine is possible as the results shown in this work. Using technological support, automated measurement of disease severity on tomato leaf gives accurate result. This avoids subjectivity, and enables to understand the extent of disease severity to optimize the amount of fungicide to be sprayed. The accuracy of disease severity estimation using image technology was found to be 96.6% as compared to the experts result. Thus, the image technology can be used efficiently for the estimation of disease severity. Moreover, estimating the exact severity level of EBT on tomato leaf minimizes the cost of fungicide to be

sprayed, saves time and energy of the cultivators, and saves the soil organisms as well as pollinators near tomato field.

4.2. Recommendations

1. Since this work specifically focused on tomato vegetable crop, further study need to be extended for other vegetable crops.
2. Other imaging techniques, such as image subtraction, segmentation on HSV color space, and FCM clustering can be used to detect EBT and estimate the disease severity in similar ways.
3. By considering this study as a kick off for disease severity estimation, further study can be carried out to check its repeatability by taking more dataset using image technology
4. Haramaya University Research office should be committed to make further study to triangulate disease detection, estimation of severity level, and optimization of fungicide to be used to manage EBT including other vegetable crops using image technology.
5. By provoking the current Ethiopian Universities to carry out more researches on image technology, the government should introduce the idea of DIP and should train development agents (DA_s) with imaging application, which enables them to assess disease severity accurately, which overcomes the subjectivity of visual assessment, to transform the existing subjective assessment into accurate assessment.

5. Acknowledgement

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3. Removal of Herbicides from Contaminated Water Using Ternary Iron (III)-Aluminum (III) - Manganese (IV) Mixed Oxide Nano-Sorbent System in Eastern Harargae Zone

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Abstract: Nanosized ternary Iron (III)-Aluminum (III)-Manganese (II) mixed oxide was synthesized by Co-precipitation method for adsorption of 2,4-D herbicide on spiked water samples from Eastern Hararghe region. The residual herbicide concentrations after adsorption process was determined using high performance liquid chromatography (HPLC) and uv-vis spectrophotometer. Surface properties of the adsorbent studied using scanning electron microscope (SEM) indicate that particles of the mixed oxide nanomaterials has well distributed pores, where 2,4-D molecules could be trapped and adsorbed. Crystal structure and phase of the powder for nanosized mixed oxide characterized by x-ray diffractometer (XRD) showed an average crystal size of 26 nm. The maximum percent adsorption efficiency of the adsorbent at an initial concentration of 10 mg/L 2,4-D and a pH of 6.0±0.1 was 89.4±1.45%. Batch adsorption studies were performed as functions of initial 2,4-D concentration, contact time, pH, adsorbent dose, and agitation speed. The experimental isotherm data were analyzed using the Langmuir, Freundlich and Dubinin–Radushkevich (D-R) isotherm equations. The Freundlich model best fits for the experimental data with a correlation coefficient (R^2=0.9996. The pseudo-second-order model best fits to the adsorption data implies that the adsorption process of 2,4-D on Al-Fe-Mn oxide Nanosorbent may be predominated by chemisorptions. The thermodynamic analysis of the equilibrium was also studied. The calculated thermodynamic parameters showed an exothermic, and spontaneous nature of 2,4-D adsorption at (298 to 328) K as indicated by the negative values of ΔG^o (-6.10kJ/mol) and ΔH^o(-3.42kJ/mol). The positive ΔS^o(0.009 kJ/mol K) values indicating the increased disorder at the solid−solution interface for the adsorption system. The reusability of the nanosized Al-Fe-Mn ternary mixed oxide was 89.4 % after five consecutive adsorption−desorption cycles. Therefore, the regeneration and reuse of nanosized Al-Fe-Mn mixed oxide for 2,4-D adsorption is quite crucial for economic costs.

Keywords: High performance liquid chromatography, Herbicides, Metal oxide nanocomposites, Batch adsorption

1. Introduction

Water resources contamination with agrochemicals and/or industrial chemicals is of growing concern. Frequent application of pesticides and fertilizers in the agricultural sector may result in contamination of water resources (Potter *et al.*, 2007). Nowadays, pesticides are indispensable for modern agriculture and pesticide spills and accidents involving pesticide handling take place each year on farms and pesticide formulating and manufacturing plants, resulting in pesticides contaminated sites. The wide spread occurrence of pesticide contamination in soils and ground water has led to intensive studies of the mobility and fate of these contaminants in subsurface environments (Peng and Keller, 2009). Pesticides are being used by human beings to protect crops since early ages. Since 19th century and onwards the

worldwide production of pesticides has increased manifold because of increasing population and the requirements of food grains. In agricultural practices these are used as insecticides, weedicides, fungicides, and herbicides and part of them is also used to control diseases like: - malaria, filariasis, dengue, cholera, and Japanese encephalitis (Vinay, 2010), but they are toxic and are potentially hazardous to human, animals, other organisms and the environment. The toxicity of pesticide is a measure of its capacity or ability to cause injury or illness (Lorenz, 2007).

Pesticides (insecticides, herbicides and fungicides) are an important group of synthetic organic chemical (SOCs) to be studied, not only because of their abundance, but also because of their toxicity to aquatic life and human. The routes that pesticides follow to enter a water body include rainfall runoff, snow melt runoff and atmospheric processes of wet and dry atmospheric depositions (To *et al.*, 2007). Especially herbicide has been a serious environmental concern because of the potential runoff and leaching of these compounds through the soil, contaminating surface and ground waters. Symmetrical triazines(s-triaiznes) are largely used as herbicides, with great emphasis to atrazine (2-chloro-4-ethylamino-6-isopropylamine-s-triazine), which has a selective action in the pre and post-emergence in agricultural soils and forestry applications. Because of the large use of atrazine (AT) to control annual grasses and broad –leaved weeds in several, in roadside verges and golf courses, intense research has been performed to investigate its environmental impacts (Gilberto and Masini,2005).Various treatment techniques and processes have been used to remove the herbicide pollutants from contaminated water (7Pereira *et al.*, 2003) which includes adsorption by activated charcoal and silver nanoparticles embedded in chitosan (Kesari and Gupta,1998),activated clay minerals, zeolites, metal oxides, agricultural wastes, biomass and polymeric materials were also tested as a potential adsorbents for pollutants (Nouri *et al.*,2002).

Along with industrial activities, agricultural activities also contribute in water pollution to the great extent. The herbicide 2,4-dichlorophenoxyacetic acid (abbreviated as 2,4-D) is one of numerous agrochemicals in use today, which is commonly used in agriculture field for controlling the broad leaf weeds and grasses, such as cocoa, rubber, and oil palm or something because of its good selectivity and low cost (Hameed *et al.*,2009). On the other hand, it has been frequently detected in water bodies in various regions of the world due to its poor biodegradation (AksuZ, 2004). 2,4-D is one of the widely known endocrine disrupting chemicals (EDCs) as well as defined as a possible B-2carcinogen and mutagen by the International Agency for Research on Cancer in 1987 other than cancer, increase in abnormal sperms, sperms immobility and death, increase of lymphocytes, probability of immune deficiency disorders, and incidence of nervous, kidney, and respiratory diseases are among the concerns associated with using this herbicide (Dehghani *et al.*, 2014). The toxicity of 2,4-D and its degradation products has become a potential hazard by contaminating ground water environment (HowardP.H,1991). Therefore, eliminating 2,4-D from raw water is extremely essential. Recently, various low –cost sorbents derived from agricultural waste or natural materials, such as sunflower oil cake, sugar beet bagasse, bamboo, coconut shell and chestnuts have been investigated for pollutant removal from aqueous solutions (Ken-Lin et *al.*, 2011).

The magnetic ion exchange (MIEX) treatment has been proven to be a good option for 2,4-D elimination. MIEX resin is a strong-base anion (chloride ion) exchange resin which can be used to absorb weak organic acidic ions from water (Ding *et al.*, 2012). Among them all the approaches proposed, adsorption is one of the most popular method due to the adsorbents are chemically stable over a wide pH range, environmentally friendly, effective treatment in dilute solutions, and economical alternative but the main problem for adsorption methods, however, is finding an efficient adsorbent. Currently, nano-particles are of great scientific interest because of their substantial mechanical properties, chemical stability and surface appearances. They are effectively forming a bridge between bulk materials and atomic or molecular structures, since bulk material should have constant physical properties regardless of its size, but at the nano-scale size-dependent properties are often observed. Thus, nanomaterials have a number of key physico- chemical properties that they have large surface area than bulk materials (Zhao *et al.*, 2010), enhanced reactivity and self assembly make them particularly attractive separation media for water

purification (Patel *et al*., 2009). The use of metal nanoparticles for environmental remediation is a relatively new area of research in which only limited progress has happened so far (Zhang, 2003).

Ternary nano-sorbent comprising of mixtures of metal oxide, clay, quartz and organic compounds are ubiquities in soils and aquatic environments and have been shown to be significant in determining the distribution of various contaminates and nutrients. These sorbents form via dissolution, adsorption, co-precipitation or colloidal interactions and often exhibit sorption behaviors compared to single component sorbents. It is the difference in this property that is believed to be primary reason for differences in sorption behavior between multicomponents and sing component solids (Mansoori, 2003).To our knowledge, no information has been reported about adsorption performance of 2, 4-D onto nanosized metal oxide sorbents. Therefore, we are motivated to work on the adsorption of the herbicides from aqueous solution by synthesizing ternary Al-Fe-Mn mixed oxide nano particle through co-precipitation method (Zhang *et al*., 2007) and interpreting the adsorption mechanism of 2,4-D to explore the equilibrium, thermodynamics, and kinetics characteristics and investigate the effect of different parameters, such as contact time, dose, initial adsorbate concentration, agitation speed and pH.

2. Material and Methods

Description of the experimental site

Synthesis of the Nanosorbent and batch adsorption experiments were conducted at Haramaya University, Chemistry Department research laboratory, XRD, SEM-EDX characterization of the synthesized adsorbent was carried out at Spanish research center, Spain, and Indian institute of technology Rookie, India. HPLC analysis after sorption of the herbicide content was conducted at JIJE analytical testing laboratory, Addis Ababa, Ethiopia.

Chemicals and instruments

Instruments that were used during the study includes, pH meter (JENWAY, Model 3310, UK), XRD (Bruker 8, Advanced XRD, AXS, Germany), Scanning electron microscopy (SEM-EDX, Japan model, Japan), High-performance liquid chromatography (HPLC, Agilent Hewlett Packard 1100 Series, USA). Chemical used in the study were ,Iron (II) nitrate heptahydrated ($Fe(NO_3)_2.7H_2O$, 99%), aluminum nitrate dodecahydrated ($Al(NO_3)_3.12H_2O$, 96%), manganese (II) nitratehepta hydrated ($Mn(NO_3)_2.7H_2O$, 98%,), hydrochloric acid,(HCl,37%), sodium hydroxide (NaOH,98%), glacial acetic acid,(CH_3COOH, 99.9%) and 2,4-dichlorophenxy acetic acid ($C_8H_6O_3Cl_2$, 97%) were purchased from Aldrich Chemicals all were of analytical grade and used without further purification.

Synthesis of Nanosized Al-Fe-Mn mixed oxide

To synthesize nanosized Fe-Al-Mn ternary mixed oxides, co-precipitation method was used $Al(NO_3)_3.12H_2O$, $Fe(NO_3)_2.7H_2O$, $Mn(NO_3)_2.7H_2O$, were dissolved in de-ionized water to form a mixed solution at a predetermined percentage of 50%, 40%, and 10% w/v respectively. NaOH(6M) was added slowly with mechanical agitation (250rpm) until the pH of the solution including the gel type precipitate reached 6.0-7.0. The precipitate was aged with the supernatant liquid for 24 h. The filtered precipitate was dried at 60-70^{o}C for 12 h in air oven. The dried product was then heat treated at 600^{o}C for 3 h in to a muffle furnace and ground with an agate mortar, sieved for fraction with 250μm molecular sieve.

The residual precipitates after treating at the temperature of 600^{o}C was labeled and used for further experiments. Energy dispersive electron microscopy (EDX) was conducted for elemental analysis of the oxides in the mixture.

Characterization of the sorbent

The physical and chemical characterization of the mixed Al-Fe-Mn oxide was carried out by scanning electron microscope (SEM) and X-ray diffraction (XRD). Energy dispersive X-ray analysis (EDX) was used for elemental analysis of the mixed Al-Fe-Mn oxide and residual concentration of herbicides after batch sorption process was analyzed by high performance liquid chromatography (HPLC) and uv-vis spectrophotometer.

Preparation and analysis of 2,4-D

By dissolving 2,4-D in deionized water, the 2,4-D containing stock solution (1000 mg/L) was prepared. The 2,4-D standard concentrations of 0, 1, 4, 8, and 12 mg/L were prepared after necessary dilutions with deionized water for batch mode adsorption studies. To quantify the amount of 2,4-D adsorbed on nanosized Al-Fe-Mn ternary mixed oxide accurately, the HPLC method was adopted to analyze the concentration of residual 2,4-D in the adsorption medium. The Agilent Hewlett Packard 1100 Series HPLC DAD System with computer (Agilent, USA) equipped with a C18 column was calibrated and tested prior to injection of the samples. Mixtures of acetonitrile (HPLC grade, ≥ 99.9 %)/ ultrapure water (25 %/75 %, with 0.1 % formic acid before mixing) were used as the mobile phase, and its flow rate was 1.0 mL·min $^{-1}$.

Batch adsorption studies

Batch sorption studies were carried out at varying experimental conditions, for studying the effect of contact time (30-150min), pH (2–11), sorbent dose (0.2-1g L^{-1}), initial 2,4-Dichloro phenoxy acetic acid standard solution concentrations (20–160mgL^{-1}) and temperature (298-328K) (Ken-Lin *et al.*, 2011). To study the other effects kinetic, thermodynamics and desorption parameters 0.4 g of the sorbent was taken in a 250 mL erlenmeyer flask, to which 100mL of standard herbicide (2,4-D) solution of known concentration was added. In each trial a test solutions were drawn out from the flask and filtered off with a Whatman No.1filter paper and the residual 2,4-D concentrations in the filtrate was measured by HPLC and uv-vis spectrophotometer. Each experiment was conducted in triplicates and the average values were reported. Making use of the initial and final concentration of 2,4-D, the percentage adsorbed and adsorption capacity of the sorbent is calculated as follows:

$$\%\ Adsorption = \frac{(C_o - C_e)}{C_o} \times 100 \quad (1)$$

$$Adsorption\ Capacity = \frac{(C_o - C_e)}{m} \times V \quad (2)$$

Where C_o and C_e are the concentrations of 2,4-D solution initially and at an equilibrium time t in mg/L, respectively and m is the dose of the adsorbent in g/L and V is the volume of the reaction mixture in (L).

Data analysis

All of the figures and model parameters (equilibrium and kinetic model) displayed in this paper were accomplished employing the nonlinear regression method of the origin 7.0 program (Origin Lab, USA). Moreover, determination correlation coefficients (R^2), as a measure of goodness-of-fit of the models was calculated as follows:

$$R^2 = \frac{(Qmeas-Qcal)^2}{\sum_{i=1}^{n}(Qmeas-Qcal)^2+(Qmeas-Qcal)^2}$$

(3)

Where Q_{meas} = the measured experiment data, Q_{calc} = the calculated data with isotherm or kinetic model, $\bar{Q}_{calc}$ = the average of Q_{calc}, and n = the number of data points.

3. Results and Discussion

SEM analysis

Scanning electron microscopy coupled with energy dispersive X-ray detector (SEM-EDX) was used to observe the morphology, particle size and composition of Al-Fe-Mn ternary oxide nanosorbent. The results obtained by scanning electron microscopy indicate that particles of the mixed oxide nanomaterials has well distributed pores, where 2,4-D molecules could be trapped and adsorbed.

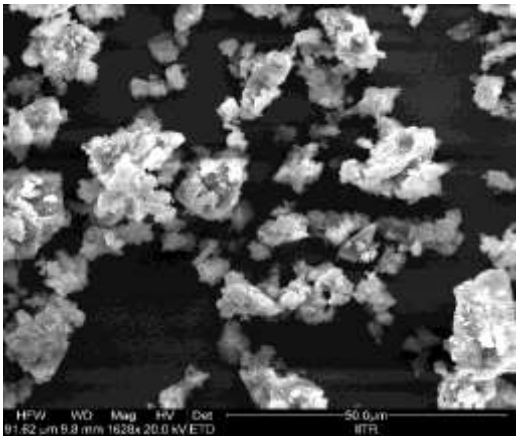

Figure1: Scanning electron microscope (SEM) micrograph for Al-Fe-Mn mixed oxide.

3.2. Powder X-ray diffraction

XRD patterns (Figure 2) of the samples show the presence of crystallized alumina γ-Al_2O_3 (2θ = 33.237) (Kumar *et al.*, 2011).

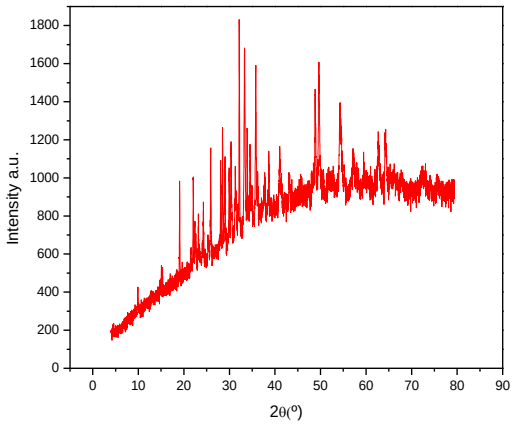

Figure 2. XRD patterns for the synthesized mixed metal oxide nano-particle.

The peaks corresponding to γ-Al_2O_3 are observed for samples as the dominant species in the mixed oxide which might be induced due to the thermal treatment at 600°C. Manganese oxide on the other hand was hardly detected in the XRD pattern and this may occur due to the presence of manganese oxide in the adsorbent was insignificant or the formation Al-Fe-Mn solid solution might have forced the Mn species to occupy interstitial holes created by the crystal lattices of Al_2O_3/Fe_2O_3 (Zhao *et al.*, 2010). The results indicate that this method simplified the extraction, identification, and quantization of the samples. Previous analysis using uv-vis techniques shows the highest concentration of 2,4-D when compared with water samples taken from Kersa, Haramaya, Chelenko, Qulube and Kerensa (0.320±0.014, 0.411±0.002,0.718±0.012,0.901±0.011,0.421±0.011mg/L)respectively.

Table 1: Average particle size for the synthesized nanomaterial

Sample no.	Calcination temp	2θ(Degree)	β (Deg)	Particle size in nm(D)
G1	600 °C	33.237	0.311	25

HPLC analysis

The HPLC and uv-vis techniques allow the accurate and reliable identification and quantization of herbicide species, included in existing priority pollutant list at or below the levels established by international regulations. The water sample for Langae(L) was used for further adsorption test using HPLC based on uv-vis analysis carried out priority. The herbicide identified and subsequently quantitated with HPLC is summarized in the Tables 2. The measured concentrations of 2,4-D in spiked water samples were between 0.380 and 1.041mg/L, with unspiked water sample Lo,(0.198 mg/L).

Table 2: Uv-vis analysis of water samples.

Sample Id	Conc.(mg/L)
Kersa(K)	0.320±0.014
Langae(L)	1.106±0.101
Haramaya(H)	0.411±0.002
Chelenko(C)	0.718±0.012
Qulube(Q)	0.901±0.011
Kerensa(Ke)	0.421±0.09

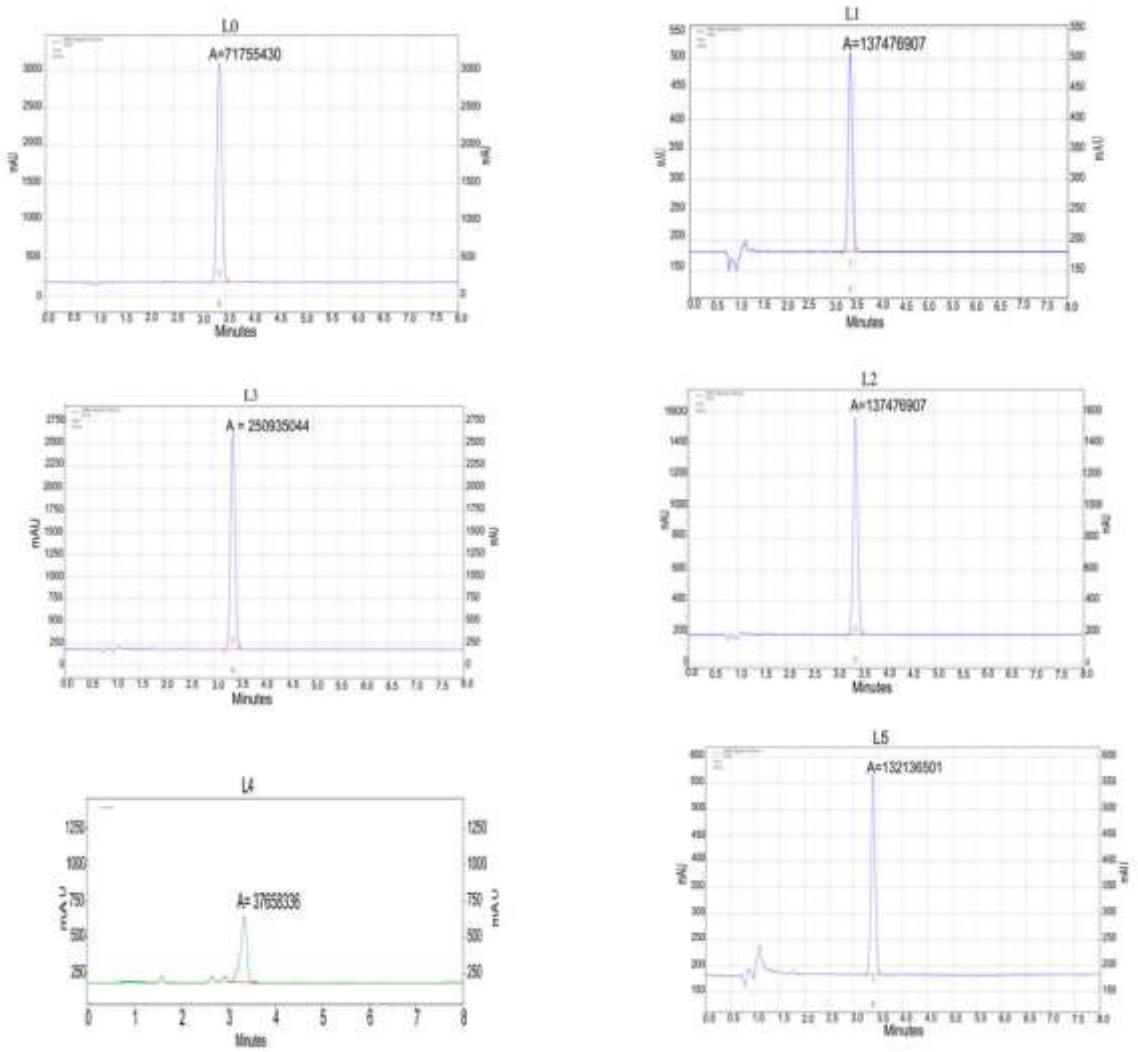

Figure 3: HPLC chromatogram for water samples L0, L1, L2, L3,L4 and L5

Table 2. HPLC analysis of water samples.

Sample Id	Peak area	Conc.(mg/L)
L0	71755430	0.198
L1	37658336	1.041
L2	137476907	0.380
L3	250935044	0.694
L4	325533796	0.901
L5	132136501	0.365

Adsorption isotherms

Freundlich adsorption isotherm

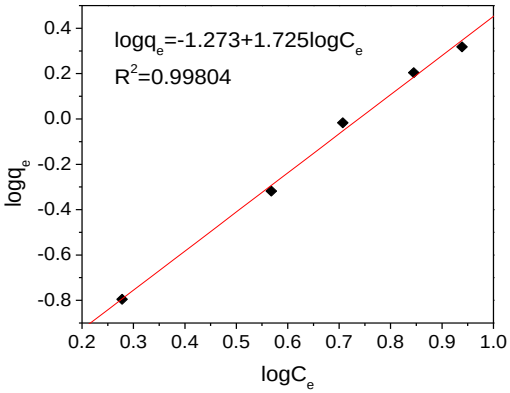

Figure 4. Linear Freundlich adsorption isotherm for 2,4-D adsorption.

The experimental data for the Freundlich parameters along with correlation coefficients were obtained by plotting log (q_e) *vs.*log (C_e) (Freundlich, 1906). As in Figure 4, a straight line was obtained with a slope of 1/n and intercepts logK_f with a correlation coefficient (R^2=0.9996). The Freundlich model best fit for the experimental data with R^2 =0.99804.The Freundlich constant K_f and 1/n was 2.528 and 0.925 respectively. The low value of 1/n (less than 1) indicates the favorable condition of the adsorption process

Langmuir adsorption isotherm

The Langmuir equation is useful for the estimation of maximum adsorption capacity corresponding to complete monolayer coverage (Langmuir I., 1918). The Langmuir model for the experimental data as shown in Figure 5 with a correlation coefficient (R^2=0.9957). Thus, the maximum sorption capacity (Q_o) corresponding to complete monolayer coverage 26.0 mg/g and the constant b which is the intercept related to adsorption intensity is 0.387 L/mg.

Table 3. Langmuir and Freundlich isotherm constants for 2,4-D adsorption.

Adsorbent	Langmuir model				Freundlich model		
Fe–Al–Mn ternary oxide	Q_o (mg/g)	b	R_L	R^2	K_f	1/n	R^2
	26.0	0.387	0.205	0.9946	2.528	0.925	0.9996

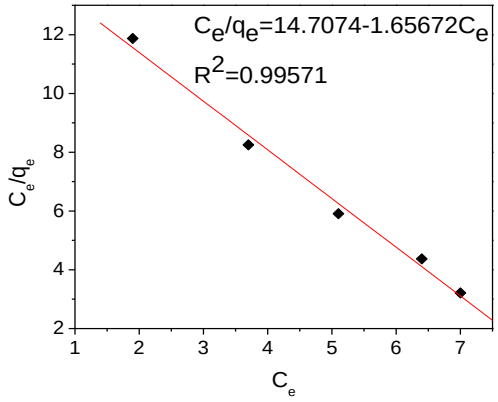

Figure 5: Linearized Langmuir adsorption isotherm for 2,4-D adsorption.

Dubinin–Radushkevich (D-R) isotherm

Dubinin–Radushkevich (D-R) isotherm is generally applied to express the adsorption mechanism with a gaussian energy distribution onto a heterogeneous surface (Dubinin, 1960). The model is given as the nonlinear form in equations 4, 5 and 6.

The model is given in non linear form by the following equations:

$$q_e = q_{D-R} \exp^{-(K_{D-R}\varepsilon^2)} \quad (4)$$

$$\varepsilon = RT\ln\left[1 + \frac{1}{C_e}\right] \quad (5)$$

$$E_{fe} = \frac{1}{\sqrt{-2K_{D-R}}} \quad (6)$$

Where q_{D-R} = the maximum adsorption capacity (mg·mL^{-1}), K_{D-R}= the D−R constant (mol^2·J^{-2}) related to the sorption energy, ε = the polanyi potential (J·mol^{-1}), R= the gas constant (8.314 J·mol^{-1}·K^{-1}), T= the absolute temperature(K), and E_{fe} = the sorption mean free energy (kJ·mol^{-1}) from the intercept and slope respectively.

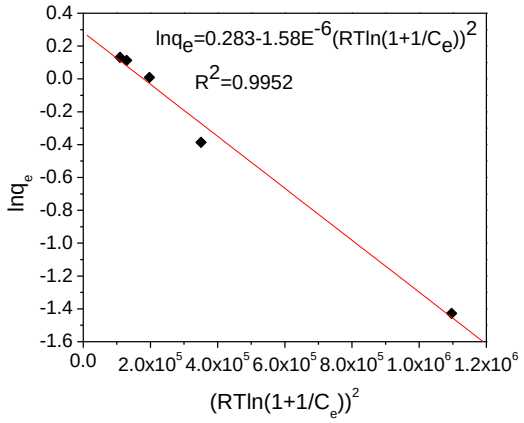

Figure 6. Plot for Dubinin–Radushkevic (D-R) isotherm.

The plot as indicated from the regression parameter R^2 (0.9951) showed that this isotherm did not provide a very good fit to the experimental data. Since the value of E_{fe} lies between 8 and 16kJ/mol the sorption process is a chemisorptions one, while values of below 8kJ/mol indicate a physical adsorption. The value of the apparent energy of adsorption (0.562kJ/mol) obtained indicated physical adsorption process between 2,4-D and nanosized ternary Al-Fe-Mn mixed oxide (Sivakumar *et al.*, 2009).

Adsorption kinetics

Adsorption kinetics is mainly to study adsorption reaction rate. It is important to quantitatively describe the adsorption rate of 2,4-D on Al-Fe-Mn oxide Nanosorbent using different kinetic models. Kinetic analysis of 2,4-D was also studied based on reaction kinetics of pseudo second order mechanism (Hamadi *et al.*, 2001) using the lagergren rate equation as shown:

$$\frac{dq_t}{dt} = k_2(q_e - q_t)$$

$$\frac{d(q_e - q_t)}{(q_e - q_t)^2} = -k_2 dt \qquad (7)$$

(8)

The integrated form at boundary conditions (t=0 to t=t) and $q_t = 0$ to $q_t = q_t$ gives:

$$\frac{1}{q_e - q_t} = \frac{1}{q_e} + k_2 t$$

$$\frac{t}{q_t} = \frac{1}{k_2 q_e^{\,2}} + \frac{1}{q_e} t \qquad (9)$$

(10)

Where q_t and q_e are amount of fluoride adsorbed at a time t and equilibrium (mg/g) respectively, k_2 is the rate constant(g mg^{-1} min^{-1}), t is the stirring time (min), k_2 which is ($slope^2$/intercept) can be determined from plotting t/q_t against t based on above equation and the value of q_e is 1/slope.

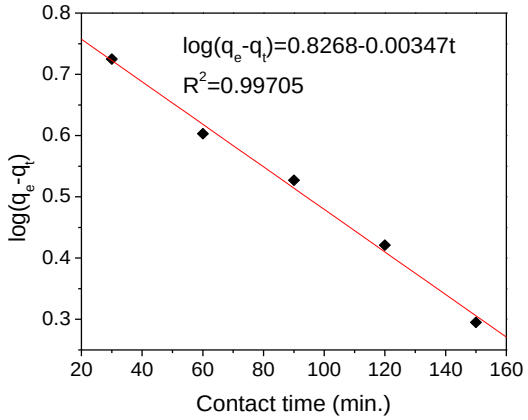

Figure 7. Pseudo first order plot for 2,4-D adsorption kinetics with initial concentration of 2,4-D, 10 mg/L, sorbent dose ,0.4 g/L and pH = 6.0 ± 0.1.

As far as the pseudo-first-order model is concerned, Figure 7 does not show good fitting to the kinetic adsorption data of 2,4-D on Al-Fe-Mn oxide nanosorbent at initial 2,4-D concentrations of 10 mg/L and a maximum sorption period (before 150 min) as shown in Figure 7.As for the pseudo-second-order model, Figure 8 shows that it gives a very good linear fitting to the adsorption of 2,4-D on Al-Fe-Mn oxide Nanosorbent at 10 mg/L 2,4-D concentrations (Ho Y.S,2007). The highest R^2 values (0.99807) indicates that the pseudo-second-order kinetic model among the models used in this study can best describe the adsorption kinetics of 2,4-D on Al-Fe-Mn oxide nanosorbent. In addition, the q_e, calculated values (5.76 mg/g) by the pseudo-second-order kinetic model also agree very well with the experimental data, q_t (4.8 mg/g) , it further confirms the applicability of the pseudo-second-order equation.

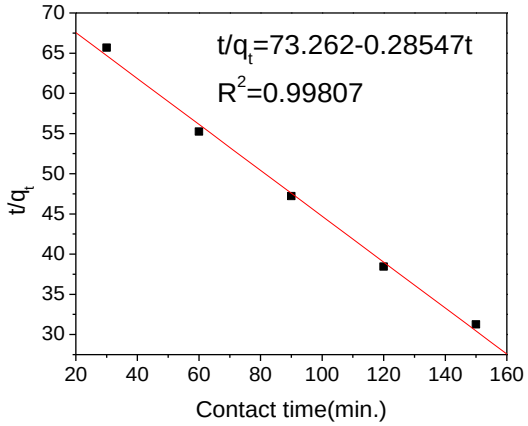

Figure 8. Pseudo second order plot with initial concentration, 10 mg/L, adsorbent dose of 0.4 g/L and pH = 6.0 ± 0.1.

Table 4. Summary of the pseudo first order rate constants and correlation coefficients.

2,4-Dmg/L)/sorbent(g/L)	($k_{1)}$(min^{-1})	Rate equation	q_e	q_{cal}	R^2
10mg/0.4g	1.11x 10^{-3}	log(q_e-q_t)=0.827.0035t	3.8 mg/g	1.46 mg/g	0 99705

Table 5. Summary of the Pseudo second order rate constants and correlation coefficients.

2,4-D(mg/L)/sorbent(g/L)	(k_2)(gmin^{-1}mg^{-1})	Rate equation	q_e	q_{cal}	R^2
10mg/0.4g	1.11x 10^{-3}	t /q_t= 73.26- 0.2854 t	4.8 mg/g	5.76 mg/g	0.99807

Thermodynamic study

Thermodynamic parameters can provide necessary information to design an adsorption process. Usually, thermodynamic parameters (ΔH^o, in KJ·mol^{-1}, ΔS^o, in J·mol^{-1}K^{-1} and ΔG^o, in kJ·mol^{-1}) are calculated using equation 11 to 14 (Liu *et al.*, 2011).

$$\Delta G = -nRTlnKc \quad (11)$$

$$InK_c = -\Delta H^o/RT + \Delta S^o/R \quad (12)$$

$$\Delta G^o = \Delta H^o - T\Delta S^o \quad (13)$$

$$K_c = q_e/c_e \quad (14)$$

Where R (8.314 J/molK) is the gas constant, T(K) is the absolute temperature and K_c is the standard thermodynamic equilibrium constant defined by q_e/C_e from langumuir isotherm. By plotting the graph of lnK_c *versus* T^{-1} (Figure 9), by computing their slope and intercept for ΔH^o and ΔS^o respectively and (ΔG^o) was calculated based on equation 13. All of the calculated thermodynamic results were summarized in Table 8.

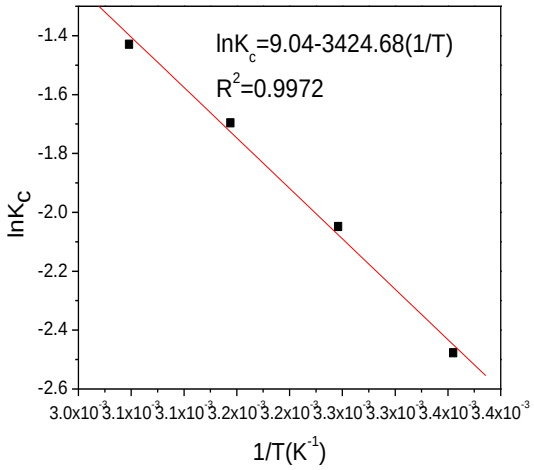

Figure 9. Plot of ln K_c *vs* T^{-1} for 2,4-D sorption on to nanosized adsorbent (dose 0.4 g/L C_o=10 mg/L and contact time 2 h.

The positive ΔS^o (0.009 kJ/molK) value indicated the increased disorder at the solid−solution interface for the adsorption system. The negative value of ΔH^o = -3.42 kJ/mol, suggests that the interaction of 2,4-D and nano Al-Fe-Mn mixed oxide is exothermic in nature (Ding *et al.*,2012). As indicated from Figure 9, the sorption process is spontaneous in nature, as indicated by the negative value of ΔG^o = -6.10 kJ/mol and the ΔG^o value increases with increasing temperature range from (298 to 328)K for the reaction indicating that it released energy to the surrounding (Xian *et al.*, 2015).

Regeneration study

The degree of 2,4-D desorption from the adsorptive materials and loaded adsorbent could be easily desorbed with NaOH solution since its effectiveness has been proven by previous studies (Zhang *et al.*, 2007). The regeneration and reuse of nanosized Al-Fe-Mn mixed oxide for 2,4-D adsorption is quite crucial for economic costs . It was found that the spent adsorbent could be well desorbed by 0.1M NaOH solutions (Dehghani *et al.*, 2014). Figure 10 showed the 2,4-D removal percentage in cycles of adsorption−desorption. It can be seen that only 10.6% loss in the removal of 2, 4-D was observed and there was still more than 89.4% of the 2,4-D adsorption percentage after 5 adsorption−desorption cycles. The results indicated that nanosized Al-Fe-Mn ternary mixed oxide resin can be repeatedly used for 2,4-D removal without a significant reduction in adsorption performance.

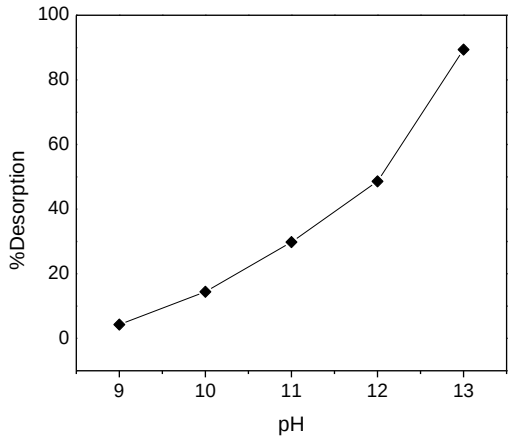

Figure 10. Desorption of 2,4-D from loaded Al-Fe-Mn adsorbent at initial [2,4-D] of 10 mg/L, pH range 9-13, adsorbent dose 0.4 g/L and equilibrium time 2 h.

Table 6. Thermodynamic parameters for 2,4-D adsorption onto nanosized adsorbent.

T(K)	ΔG^o (kJ/mol)	ΔH^o (kJ/mol)	ΔS^o (kJ/molK)
298	-6.10	-3.42	0.009
308	-6.19		
318	-6.28		
328	-6.37		

Thus, it can be concluded that the adsorbent could be regenerated and used for many times for separation application.

4. Conclusions

The study showed the adsorption of 2,4-D on nanosized ternary Al-Fe Mn mixed oxide. The maximum percent adsorption efficiency of the adsorbent at an initial concentration of 10 mg/L 2,4-D and a pH of 6.0±0.1 was 89.4±1.45%. Equilibrium studies showed the 2,4-D adsorption process best fit the Freundlich isotherm model with R^2=0.9996. The calculated thermodynamic parameters showed an exothermic, and spontaneous nature of 2,4-D adsorption at (298 to 328)K as indicated by the negative values of ΔG^o (-6.10KJ/mol) and ΔH^o(-3.42KJ/mol).The positive ΔS^o (0.009kJ/molK) values indicated the increased disorder at the solid−solution interface for the adsorption system. Kinetic evaluation of experimental data showed that the adsorption processes of 2,4-D followed well pseudo-second order kinetics however the Elovich kinetic model does not give a good fitting to the adsorption data. The value

of the apparent energy of adsorption (0.56kJ/mol) obtained followed physical adsorption process between 2,4-D and nanosized ternary Al-Fe-Mn mixed oxide evaluated from the D−R model. The recovery tests indicated that 2,4-D from the spent nanosized ternary oxide could be desorbed by NaOH solutions, and the reusability of the nanosized Al-Fe-Mn ternary mixed oxide was 89 % after five consecutive adsorption−desorption cycles. Thus, it can be concluded that the adsorbent could be regenerated and used for many times for the removal of the pesticide.

5. Acknowledgments

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4. *Datura stramonium* L. Seed Oil; Alternative Locally Available Non-edible Feedstock Source for Biodiesel Production in Ethiopia

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Abstract: A biodiesel was produced from locally available *Datura stramonium* L. seed oil by transesterification using methanol as a reagent and sodium hydroxide as a catalyst at an optimumtemperature of 55^{o}C. In this experiment a yield of 86.67% (w/w) biodisel was obtained. A gas chromatography mass spectroscopy (GC-MS) was used to analyze the organic compounds present in the biodiesel. The GC-MS analysis revealed that, the biodiesel is composed of two major unsaturated methylesters (methyllinoleate 48.60% and methyl oleate 34.20%) and saturated methyl esters (palmitate 12.88% and methyl stearate 3.04%). The biodiesel was further characterized according to ASTM 6751 and EU14214 standard requirements. The results of the biodiesel properties showed that 0.08 moisture content, and density at 15^{o}C and 25^{o}C was 0.8861 g/mL and 0.8826 g/mL, respectively specific gravity at 25^{o}C was 0.887g/ml, kinematic viscosity at 40^{o}C, 4.7 mm^{2}/s; refractive index 1.46, pH 6.46, colour 1.5, water and sediment less than 0.05, saponification value 101.6mg KOH/g oil, cloud point, +8^{o}C; flash point less than 186 ^{o}C , total acidity 0.41mg KOH/g,copper strip corrosion 3 h at 100^{o}C and ash content 0.001 % mass. Analysis results are in good agreement with the standard values given by ASTM D6751 and EU14214 specifications for biodiesel. Thus, the physicochemical properties test of D. Stramonium L. Seed Oil biodiesel exhibited the minimum requirement of biodiesel , therefore, it is recommend for use as biodiesel.

Keywords: Datura stramonium, biodiesel; transesterification; physiochemical properties

1. Introduction

In today's societies, there are diminishing petroleum reserves and increasing environmental consequences of exhaust gases from petroleum-fueled engines. Fossil fuel is a problem both in developed and developing countries (Ntagandaet al., 2014). An increased necessity for energy independence and heightened concern about the effects of increasing carbon dioxide levels have intensified the search for renewable fuels that could reduce our current consumption of fossil fuels (Timothyet al., 2008). Among various alternative fuels produced from renewable resources, biodiesel, which is well known as a replacement for the traditional petroleum diesel fuel is currently becoming a fast-growing market product.

Biodiesel is a fuel obtained from renewable biological sources such as vegetable oils both (edible and nonedible oil). It composed of mono-alkyl esters of long chain fatty acids derived from plant and animal oils and fats by transesterification with short carbon alcohols such as methanol. Transesterification is the reaction of a lipid with an alcohol to form esters and a byproduct, glycerol. Its reaction process usually involves the use of short chain alcohols such as methyl or ethyl alcohol and a catalyst is normally used to speed up the reaction (Ngadi et al., 2013). Short-chain alcohols such as methanol, ethanol, and butanol are the most frequently employed. The selection of the alcohol is based on cost and performance

consideration. For transesterification process methanol was commonly used. Because methanol is cheaper than ethanol and the recovery of unreacted methanol is easier (Mathiyazhagan *et al.,* 2011).

Biodiesel produced from plants and agricultural wastes may have the potential to cut global warming pollution, enhance energy security, and strengthen local economies. One way of reducing the biodiesel production costs and avoiding consequences of environment pollution and famine is to use the less expensive feedstock containing fatty acids such as nonedible oils, animal fats, and waste food oil and by-products of the refining vegetables oils (Ntaganda et al., 2014).

Biodiesel is a non-toxic, biodegradable, and renewable diesel fuel and can be used neat or blends with petroleum diesel fuels. Biodiesel has many advantages compared to diesel fuels. It has higher cetane number than diesel fuel, and contains no aromatics, almost no sulfur and 10-12% oxygen by weight. Biodiesel-fueled engines produce less carbon monoxide, hydrocarbons and particulate emissions than petroleum diesel-fueled engines. Biodiesel improves the lubricity, which results in longer engine component life (Sivaramakrishnan et al., 2012). In addition to this, the increased environmental concern and the expected decrease of petroleum reserves are the main reasons for the exploration of alternative non-edible crops for biodiesel production (Archana et al., 2011)

Ethiopia being an agricultural country endowed with varied climates, nutrient rich soil and ability to grow many different crops, Ethiopia offers a great promise as a producer of surplus raw material for biodiesel. Exploitation of edible oil for biodiesel production is restricted in the country due to its competition for food resources. Many researchers in the field of biofuel reported that non edible plants oil possess a clear potentials source of biofuel which replaces fossil fuel in view of economic as well as environmental benefits. According to Azam et al., (2005), the use of edible oil in developing country such as India is not feasible for the production of biodiesel. Edible oil compute for food and their prices are relatively increase compared to non-edible oil. Under these conditions only such plants which produce non-edible oils can be considered for biodiesel, and they can be grown in large scale on non-cropped marginal lands and wastelands. Therefore, this study emphasized on the laboratory scale study for the development of clean, new and renewable energies, particularly biodiesel extraction from locally available non-edible *Datura stramonium* oil, as an alternative solution to hydrocarbons (fossil fuels)and evaluate the biofuel properties of the plant, in response to the rise in oil prices which has adverse effects on the economies of the country.

2. Materials and Methods

Plant Materials

The matured ripe seed of *Datura stramonium L* were collected from Haramaya woreda, Eastern part of Ethiopia. The collected seeds were cleaned, de-shelled, air dried and grounded into a fine powder using an electric grinder prior to oil extraction.

Experimental Procedures

The powdered *Datura stramonium* seed (2.11kg) was extracted in the Soxhlet extractor apparatus for 6 hours using petroleum ether (40^oC-60^oC) as an extract solvent. The extracted oil was recovered by solvent evaporation using rotary evaporator at 50^oC under reduced pressure. The amount of oil in seed was determined using the equation below.

$$\%\ \text{oil extracted} = \frac{\text{Mass of extracted oil}}{\text{Mass of powdered } Datura stramonium \text{ seed}} x100$$

Transesterification reaction and Purification

From concentrated oil, 650ml of oil was measured and heated to a temperature of 55°C using a water bath. A solution of sodium methoxide (3.25g of NaOH pellet and 135.5ml of anhydrous methanol) was prepared and properly stirred until the NaOH pellet was completely dissolved. The sodium methoxide ($NaOCH_3$) solution was poured into the warm oil and stirred vigorously for about 90 minutes using a magnetic stirrer. After settling the mixture for 24hours in a separating funnel, the lower which comprises of glycerol, soap and other impurities as dark brown colored liquid was collected from the bottom of the funnel. Then the methyl ester layer was washed by hot distilled water several times to remove any remaining unreacted methanol, glycerin, catalyst, soaps and other impurities until the wash water drained out is clear. The percentage of methyl ester (biodiesel) yield was calculated. The quantity of biodiesel was collected, measured and recorded for further analysis.

$$\text{Yield of methyl esters \%} = \frac{Weight\ of\ methyl\ esters\ produced\ (gm)\ X\ 100}{Weight\ of\ seed\ oil\ taken\ in\ (gm)}$$

3. Result and Discussion

Percentage of oil extracted from Datura stramonium L. seed

Through solvent extraction, 30.84% (w/w) of oil *was obtained* from *Datura stramonium L.* seed. The result showed that *Datura stramonium L.* seed is good source of oil. Ntaganda et al., (2014) reported that *Jatropha curcas* seed oil (26.88%), which is less than *Datura stramonium L.* seed oil content. When we compare, the two results *Datura stramonium L.* seed has better oil content than *Jatropha curcas* seed oil.

Purification processes of biodiesel

After transesterification reaction and settling for 24hrs for phase separation, the methyl ester layer was washed by hot distilled water several times to remove any remaining methanol, glycerin, catalyst, soaps, free fatty acid, glycerides and other impurities. The water in the methyl ester was evaporated by heating at 105°C. The remaining unreacted methanol in the biodiesel has safety risks and can corrode engine components, the residual catalyst (sodium hydroxide) can damage engine components, and soap in the biodiesel can reduce fuel lubricity and cause injector coking and other deposits (Indhumath *et al.*, 2014).

Percentage of biodiesel produced from Datura stramonium L. Seed Oil

From *Datura stramonium* L. seed, 86.67% (w/w) methyl ester was recovered. The result indicates that *Datura stramonium L.* seed is good source of biodiesel compared to other non-edible plants. Ntagand *et al.,* (2014) reported that biodiesel obtained from *Jatropha curcas was (*85.03 % wt); and Mango Seed Oil (83 % w/w) (Umaru *et al.,* 2014). However, another study conducted on the same plant by Wang *et al.,* (2012), reported similar result (87%). Decreasing amount of biodiesel is due to un-reacted alcohol, residual catalyst and emulsion removed during the washing stage of the production process. Similar observations had been reported by (Viele *et al.*, 2014).

Physicochemical properties of biodiesel produced from Datura Stramonium L. Seed Oil

The physicochemical properties result obtained from *Datura Stramonium L.* Seed Oil is presented in Table1. Some of these results were compared with the biodiesel produced from Jatropha oil by Ntaganda *et al.,* (2014), from the same plant **(***Datura Stramonium L.* Seed Oilsoil) by Wang *et al.*, (2012)and ASTM D 6751 and EU 14214 standard of fuel properties.

Moisture content of biodiesel

The moisture content of currently determined *Datura Stramonium* L. methyl ester was 0.08 which was slightly higher than ASTM and EU method. This might be due to the purification processes which were carried out by water. Moisture content in oils is a great impediment to the formation of esters due to increase in tendency of soap formation and thus will have to be minimal for transesterification to occur. Nurudeen et al., (2014) reported that in the catalyzed methods, the presence of water has negative effects on the yields of methyl esters because the feedstock is prone to soap formation rather than biodiesel. Higher free fatty acids which are justified by its acid value. However, the pH of biodiesel obtained was higher than the biodiesel prepared from *Callophyl luminnophyllum* (pH=5.7) (Ariharan. et al., 2014).

Density and specific gravity of biodiesel

The density of biodiesel at 15^{o}C and 20^{o}C were 0.8867g/mL and 0.8826g/mL respectively. Higher density of the liquid fuels affects the flow properties of the fuel, such as spray atomization, subsequent vaporization and air-fuel mixing in the compression chamber. The change in spray can greatly alter the combustion properties of the fuel mixture (Ariharan. et al., 2014). According to EU the acceptable density range is between 0.860–0.900 g/ml. From Table 1, it has been shown that results obtained from ranged within the acceptable limit. This result also matched with biodiesel produced Jatropha curcas seeds oil cultivated in Rwanda (Ntaganda et al., 2014). The specific gravity of biodiesel obtained was 0.887 g/mL which is within the acceptable limit.

Refractive index of biodiesel

Table 1 shows that refractive index of biodiesel obtained was 1.458. Refractive index is close to 1.4570 reported by Ntaganda et al., 2014 for biodiesel produced from Jatropha curcas seeds oil cultivated in Rwanda. Higher the refractive index, the greater degree of unstauration or conjugation and vice versa (Omari1,et al., 2015). This result was in agreement with GC-Ms results which revealed that unsaturated methyl esters were found higher in percentage.

The pH of biodiesel

As can be seen in Table 1 above, the pH value of biodiesel (pH = 6.46) is less than the pH value of petro diesel (pH = 6.8). This indicates the presence of some fatty acid in the biodiesel.

Kinematic viscosity of Biodiesel

Kinematic viscosity is a measure of resistance of fluid flow under the influence of gravity which is a basic specification for the fuel injectors used in diesel engines and when viscosity is high injectors do not perform properly (Gerpen *et al.,* 2005). The greater the viscosity of oil, the less easily it was flowed. Thus, transesterification reaction reduced density and kinematic viscosity (Sivaramakrishnan et al., 2012). As can be seen in Table 1, the kinematic viscosity of biodiesel at 27^{0}C was 4.7mm^{2}/s. The viscosity of biodiesel (4.7mm^{2}/s) obtained is quite in agreement with the EU (3.5-6mm^{2}/s) and ASTM (1.9-6mm^{2}/s) standard and the value obtained from the same plant (Wang et al., 2012). However, higher kinematic viscosity (7.891 at 20°C) has been reported for biodiesel from Jatropha curcas seeds oil cultivated in Rwanda(Ntaganda et al., 2014). The results obtained in this study suggest that, the biodiesel obtained from seeds of *Datura stramonium L.* oil was good for biodiesel production.

Table 1. Physicochemical properties of the *Datura Stramonium L.* Seed Oil–biodiesel and Comparison with Standards (ASTM D6751, EU 14214) and literatures.

Parameters	Test Method AS TM	Biodiesel	USA ASTM D 6751	EU EN 14214	DSO biodiesel (Wang et al., 2012)	Jatropha biodiesel (Ntaganda et al., 2014)
Moisture content	-	0.08	0.03	0.05	0.5	
pH	-	6.46				
Density at 15°C (g/mL)	D4052	0.8861	-	0.860 –0. 900		
Density at 20°C (g/mL)	D4052	0.8826	-	0.860 –0. 900		0.876566
Specific gravity (g/mL)	-	0.887	0.865-0.885			
Refractive index at 25°C	-	1.458	-	-		1.4570 20°C
Kinematic viscosity at 40°C(mm^2/s)	D445	4.7	1.9 – 6.0	6.0 – 3.5	4.33	7.891 at 20°C
Color	D1500	1.5	-			
Water and sediment (%V)	D2709	<0.05	Max. 0.05	-		
Saponification value (mgKOH/g)		101.6				
Flash point (PMCC).	D93	>186	Min. 130	Min. 120	161.5	
Copper strip corrosion 3hrs at100°C	D130	1a	Max. No 3	Max. No 1	1a	
Cloud point.	D2500	+8	Report			
Total acidity (mgKOH/g)	D974	0.41	0.5(D664)		0.1	2.5245
Ash content, mass %	D482	0.001	Max.0.01			

Color

The color of the biodiesel produced from the *Datura stramonium L seed oil* became light brown from light yellow within one and half hours. The color can be improved by bleaching the used oil before biodiesel production. This is likely to increase the cost of production (Ngadiet al., 2013).

Water and sediment %v

Biodiesel is also potentially subject to hydrolytic degradation caused by the presence of water. Fuel contaminated with water can cause engine corrosion and breakdown. Biodiesel contaminated with water can also cause reaction with glycerides to produce soaps and glycerol and serve as media for bacteriological growth, leading to filter blockage. Due to these negative effects, ASTM set the maximum allowable content of 0.05% for water in biodiesel (Fanet al., 2009). From the results obtained, biodiesel from *Datura stramonium L seed oil* has traces of bottom water and sediment less than 0.05% volume. This value confirms it is in the range of to the ASTM set standard whose maximum acceptable limit is 0.05% volume. Since methyl ester has a negligible amount of bottom water and sediment, it is better quality of biodiesel.

Total acidity

The total acidity of biodiesel obtained from this work was 0.41mgKOH/g. This result agrees with the ASTM maximum allowable limit (0.8) and EU maximum allowable limit (0.5). This parameter can also be used to measure the freshness of the biodiesel. The higher the acid value the lower the quality of the fuel (Umaruet al., 2014)

Saponification value

Saponification value represents the number of milligrams of potassium hydroxide required to saponify 1g of oil. It is a measure of the tendency of the oil to form soap during the transesterification reaction. The high saponification values obtained indicates high presence of fatty acids which might lead to soap formation (Belloet al., 2015). The saponification value of biodiesel was 101.6 mgKOH/g which indicating the presence of fatty acids. This might lead to soap formation.

Kinematic viscosity

Kinematic viscosity is a measure of resistance to flow of a liquid due to internal friction of one part of the fluid moving over another. High viscosity affects the atomization of a fuel upon injection into the combustion chamber and thus leads to the formation of engine deposits (Allenet al., 1999). The kinematic viscosities of biodiesel from *Datura stramonium L seed oil* was determined to be 4.7mm^2/s and when compared to ASTM, it was seen that the viscosity of biodiesel within range of acceptable standard.

The flash point

The flash point is the lowest temperature at which an applied ignition source will cause the vapours of the fuel to ignite. It is therefore a measure of tendency of a sample to form a flammable mixture with air. The flash point obtained for biodiesel from *Datura stramonium L seed oil* was less than 186^{o}C. This value lies within the notable ASTM and EU standards and also in close proximity to the reported value for biodiesel from Jatropha curcas seeds oil cultivated in Rwanda (Ntaganda et al., 2014) and the biodiesel obtained from seeds of *Datura stramonium L.* oil (Wanget al., 2012). The high value obtained in this study clearly signifies that the biodiesel produced is basically free from methanol; this is because even small quantity of methanol can reduce the flash point (Umaru *et al.*, 2014).

Cloud point

Cloud point of fuel is the temperature at which a cloud of wax crystals first appears when the fuel is cooled (Viele *et al.*, 2014). It used for low temperature performance of a fuel and most common measure of the tendency of a fuel to crystallize which has implication on the use of biodiesel in cold weather applications. The cloud point of biodiesel from *Datura stramonium L seed oil* was determined at 8^{o}C. This might be forming cloudy crystals easily in cold temperature.

Copper strip corrosion

Copper strip corrosion determines the biodiesel's destructive capabilities to metals. The copper strip corrosion copper strip was heated at 100°C in a biodiesel bath for three hours. The result obtained (3hrs at100^{o}C) was 1a which is within range of the maximum limits specified by both EU (1a) and ASTM (Maximum value of 3a). This indicated the produced biodiesel could not tarnish the copper strip. Comparative results (1a) have been obtained from the same plant reported by Wang *et al* 2012.

Ash content mass (%)

The ash content of biodiesel was 0.001% which is less than the maximum value settled by ASTM (0.01%) standard. This indicates that there is no solid materials resulted from catalysts during transesterification reaction and this makes it more eco-friendly as compared to other biodiesel sources. This also helps in determining the other additives if any present in the oil.

Gas chromatographic (GC) analysis of fatty acid methyl esters (FAME)

Fatty acid methyl esters profile of the biodiesel produced from *Datura stramonium L seed oil* was determined by GC-MS analysis. The individual peaks of the gas chromatogram (Fig 1) were analyzed and the methyl esters components also identified. The result of the gas chromatographic analysis is shown in Fig 1. The individual peaks of the chromatogram were analyzed and the methyl esters components also identified. From the chromatographic analysis result shown in Figure 1 and Table 2 above *Datura Stramonium L.* seed oil-biodiesel consists of two major unsaturated methyl esters (methyl linoleate 48.61% and methyl oleate 34.20%) and two saturated methyl esters *(*palmitate 12.88% and methyl stearate 3.03%). The unsaturated methyl esters were 82.81% which was higher in percentage while saturated methyl esters only 15.91% present as minor constituents. This indicates that the *Datura Stramonium L.* seed -biodiesel composed mainly of unsaturated methyl esters.

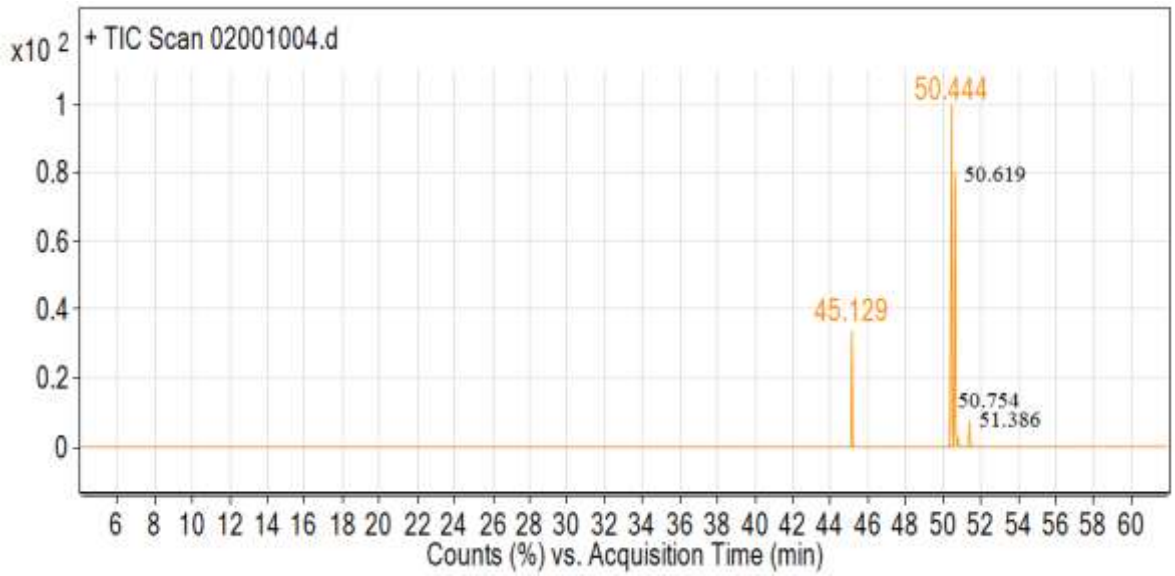

Figure 1.GC-Chromatogram of Methyl ester of *Datura stramonium* seed oil.

Table 2. Relative percentage of methyl esters Profile of *Datura Stramonium L.* seed oil using GC- MS.

No.	Composition	Retention time	Formula	Symbol	Amount (%)
1	*Methyl linoleate*	50.444	$C_{19}H_{34}O_2$	C18:2	48.61
2	*Methyl oleate*	50.619	$C_{19}H_{36}O_2$	C18:1	34.20
3	*Methyl palmitate*	45.129	$C_{17}H_{34}O_2$	C16:0	12.88
4	Methyl stearate	51.386	$C_{19}H_{38}O_2$	C18:0	3.03
5	Others	50.754	-	-	1.28

3. Conclusion and Recommendation

3.1. Conclusion

Alkali catalyzed transestrification under optimal reaction conditions; maximum methyl ester yield (86.67%) was produced. All physio-chemical parameters tested were comparable and met with ASTM D 6751, EU standard and other reported values of biodiesel properties. Therefore, as a cheap feedstock, *Datura Stramonium L.* seed oil can be potentially used as a raw feedstock for biodiesel production on a commercial scale. Locally available non-edible oil of *Datura Stramonium* seed which will not lead to food crisis can be used for biodiesel production. From the four major methyl esters identified in *Datura. Stramonium* seed biodiesel, 82.81% of them are unsaturated and 15.91% are saturated. Generally, from our results, we conclude that the biodiesel produced from *Datura stramonium* seed oil met the standards set for acceptable fuel properties.

3.2. Recommendation

Two-step reaction is preferred to reduce high FFA content, acid pretreatment followed by alkali-catalyzed transesterification. The oil was extracted using solvent extraction method by petroleum ether. This solvent method is not recommended for commercial production of biodiesel. This is because of high cost of petroleum ether and it was time consuming so, better if other extraction method to be used. Better if other researchers can carry out further studies on other physicochemical parameters like: catene number, iodine value, peroxide value etc. of *Datura stramonium* biodiesel properties. As the *Datura stramonium* seed has rich with oil content and good potential to be grown in Ethiopia, it is therefore recommended that the plant should be cultivated on large scale production to produce the oil that can be transesterification into an acceptable ecofriendly biodiesel. It is also good, if further investigation to be conducted on *Datura stramonium seed oil* for biodiesel production to be commercialized to replace environmentally unfriendly, high cost, and non-renewable petrol diesel.

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5. Biosupported $ZnO\text{-}TiO_2\text{-}Fe_2O_3$ Nanocomposite for Wastewater Treatment from HU Effluents

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Abstract: This study was carried out to investigate the efficiency of bioadsorbents from Egg and Peanut shells impregnated with $ZnO\text{-}TiO_2\text{-}Fe_2O_3$ nanocomposite for wastewater treatment. A total of ten nanocomposites of $ZnO\text{-}TiO_2\text{-}Fe_2O_3$ with different ratios of precursor salts were prepared by gel evaporation method using precursors $Fe(NO_3)_3.9H_2O$, $Zn(NO_3)_3.6H_2O$, and $TiCl_4$, by varying the content of iron and titanium and using zinc as host. All the as-synthesized nanocomposites were characterized using x-ray diffraction through which four of them were selected based on their smallest size. The selected nanosized powders were further characterized using energy dispersive x-ray spectroscopy, scanning electron microscopy and transmission electron microscopy. The absorption spectrum and band gaps energy of each as-synthesised nanocomposite were determined by uv-vis spectroscopy. The effects of operating parameters such as pH, dose of the adsorbent, contact time, initial concentration, and agitation speed were investigated. The experimental isotherm data were analyzed and found to be fit well with both Freundlich and Langmuir isotherm models. The kinetic data were correlated with the pseudo-first and pseudo-second order kinetic model for the sorption studies. The experimental data revealed that the pseudo-second order model better represented the metal ion adsorption kinetics, suggesting that more of the adsorption process might follow second order chemisorptions process.

Keywords: Bioadsorbents; Impregnation; Gel evaporation; Nanocomposites

1. Introduction

Due to rapid industrialization and urbanization in developing countries like Ethiopia heavy metal pollution is a serious problem today and its treatment is of special concern due to their persistence in the environment. Like organic pollutants, most of these heavy metals do not undergo biological degradation, resulting into harmless end products (Gupta *et al.*, 2001**).** Several heavy metals removal technologies including chemical precipitation, ion exchange, reverse osmosis, electrodialysis, ultra filtration and pyhtoremediation are commonly used in industries. However, these technologies are becoming uneconomical and unfavorable (some of them produce large toxic sludge like precipitation) to remove heavy metals from industrial wastewaters **(**Ahalya *et al.,* 2005). As a result, the effluent treatment in developing countries is expensive. The indigenous production of treatment techniques that use locally available non-conventional materials to treat pollutants seems to be the solution to the increasing problem of treatment of effluents.

Biosorption is the ability of biological materials to accumulate heavy metals from wastewater through metabolically mediated or physico-chemical pathways of uptake **(**Fourest, 1992**).** It involves a solid phase (sorbent or biosorbent; usually a biological material) and a liquid phase (solvent, normally water) containing a dissolved species to be sorbed (sorbate, a metal ion). Due to higher affinity of the sorbent for the sorbate species the latter is attracted and bound to the former through different mechanisms. The

process continues till equilibrium is established between the amount of solid-bound sorbate species and its portion remaining in the solution. While there is a preponderance of solute (sorbate) molecules in the solution, there are none in the sorbent particle to start with. This imbalance between the two environments creates a driving force for the solute species. The heavy metals adsorb on the surface of biomass thus, the biosorbent becomes enriched with metal ions in the sorbate. Biosorption of metal ions using biological materials such as algae, bacteria, fungal and yeast; and agricultural wastes have received greater attention due to its advantages over conventional methods (Aksu, 2005**).** Both living and nonliving microorganisms such as algae, bacteria, fungal, yeast and waste of food and agricultural industry were used as biosorbent materials for heavy metals biosorption (Wang, 2006)**.** Focus on using these microorganisms as well as wastes of food and agricultural industries as biosorbent for metals removal was searched as it is cheap and abundant (Kapoor, 1997).

The idea of using various agricultural products and byproducts for the removal of heavy metal from solution has been investigated by a number of authors. Friedman and Waiss, (1972); Randall *et al.* (1974) and Henderson *et al.* (1977) have investigated the efficiency of number of different organic waste materials as sorbents for heavy metals. Besides this, biosorption offers advantages of low operating cost, minimizes the volume of chemical and/or biological sludge to be disposed of (no toxic sludge produced at the end of the process because it can be recycled), is highly efficient in dilute effluents and has no nutrient requirements. These advantages have served as potential incentives for promoting biosorption as a viable clean-up technology for heavy metal(s) pollution (Volesky, 1993**).** The use of *Teff* straw can be considered as one of the most promising, natural, easily accessible, and low-cost adsorbent for efficient and quantitative removal of Cr(VI) from contaminated waste waters released from leather industries (Bezuayehu *et al.,* 2015).

Efficient synthetic methods to obtain shape-controlled, highly stable, and monodisperse metal oxide nanomaterials have been widely studied during the last decade (Vanbenschoten *et al.*, 1994)**.** It has been reported that bulk and nanoparticle TiO_2 anatase were able to simultaneously remove multiple metals (Zn, Cd, Pb, Ni, Cu) from a solution of pH = 8 from tap water. When adsorption capacities were normalized by mass, the nanoparticles adsorbed more than the bulk particles. The presence of common cations and anions (100–5000 mg/L) has no significant influence on the targeted metal (Zn^{2+} and Cd^{2+} ions of 1.0 mg/mL) adsorption under the given conditions.As an adsorbent, nano-szed ZnO was mostly applied to eliminate H_2S. Recently, people have found that nanostructured ZnO could efficiently remove heavy metals (Wang *et al.*, 2010). Lee *et al.* (2005) prepared nanometer size zinc oxide (ZnO) powder by "solution-combustion method (SCM)". Compared with two titanium dioxide powders, the zinc oxide nanopowder showed higher removal rate of Cu^{2+} ions from the solution (Jing *et al.*, 2008).

Besides some properties similar to TiO_2, ZnO nanoplates has many unique advantages, such as simple and cheap to prepare, convenient to tailor morphologically (Ma *et al.*, 2010). These nanoplates have an adsorption capacity of >1600 mg/g for Cu (II) ions. The adsorption isotherm is subject to the Freundlich equation (K_f = 324.22 (mg/g/mg), n = 4.56), while the commercial ZnO nanopowders follow a Langmuir isotherm model. In addition, the metal sorbed nano-ZnO can be employed to fabricate other environmental materials. Ma *et al.* (2010) reported a novel strategy to prepare ZnO/PbS heterostructured functional nanocomposite based on Pb^{2+} sorbed ZnO. In brief, ZnO nanosheets prepared via a hydrothermal approach were used to adsorb Pb^{2+} and then hydrothermally treated in aqueous solution containing sulfur source. Due to the surface hydroxy groups, the resultant ZnO nanosheets exhibited a good capacity to Pb^{2+} as 6.7 mg/g.

The huge amount of *Egg* and *Peanut* shells from the country indicates the likely increase in quantities of these residues from their disposal units. Therefore, if the out come of this research reveals that the egg and peanut shells are an efficient adsorbent for heavy metals it would provide a dual advantage of minimizing the large quantity of *Egg* and *Peanut shells* of near polluting water and use this cheap byproduct for industrial waste treatment. Most of these metals were present in our environment only in minute amounts until recent centuries, when the orientation toward industrialization and production brought

about our many technological advances. At present, these toxic metals have polluted our atmosphere, our waters, our soil, and food chain (Ko *et al.,* 2000***).*** However, these technologies are becoming uneconomical and unfavorable (some of them produce large toxic sludge like precipitation) to remove heavy metals from industrial wastewaters. As a result the effluent treatment in developing countries is expensive. The indigenous production of treatment techniques that use locally available non-conventional materials to treat pollutants seems to be the solution to the increasing problem of treatment of effluents. Searching for a low cost and easily available adsorbent has led to the selection of materials from agricultural and biological origin, along with industrial by-products, as adsorbents. Biological treatment using either living or dead microorganisms or plants, offers unique capabilities to concentrate and reduce the levels of heavy metals to environmentally acceptable limits in a economically and environmentally friendly manner (Volesky, 2001).

The main reasons for taking interests in developing an efficient bio-sorbents from egg and peanut shells impregnated with ZnO-TiO_2-Fe_2O_3 Nano-composite for wastewater treatment from HU effluents are primarily the researchers experience in observing the uneconomical disposal of wastewater resources from the University's sewage system and secondly there still is a gap for a sound research base in finding an efficient water treatment technologies for removing heavy metal contaminants. Therefore, the study attempted to investigate and test the adsorption efficiency of the synthesized nano composite imprgenated with bio-sorbents system for removal of heavy metal in contaminated water that may cause acute health impact on human beings living in the area in addition to the uneconomical wastage of these resources that can be treated and applicable for other household puposes.

2. Materials and Methods

Experimental Site

Fresh *Egg* and *Peanut* shell samples were collected from Haramaya University Student's Cafeteria and Haramaya University Babile Research Center, respectively, and wastewater samples were colleted from Haramaya University main campus of student's cafeteria (M), Laboratory (LA) and staff residence effluents(R). Synthesis of the nanocomposites, preparation of the bioadsorbents sand batch mode adsorption studies for individual metal ions were carried out at Chemistry Department Research Laboratory, Haramaya University. XRD characterization of the synthesized nanocomposite was done at Geological survey of Ethiopia. EDX and SEM analysis of the selected as-synthesized powders were done at University of Cape Town, South Africa.

Apparatus and instruments

X-ray diffractometer (BRUKER D8 Advanced X-Ray Powder Diffraction, AXS GmbH, Karisruh, West Germany) was used for the characterization of the as-synthesized powders. Electrochemical analyzer CHI630 was used to measure the cell performance of the as-synthesized nanocomposites. Other apparatus like pH meter, analytical balance, magnetic stirrer, mortar and pestle, crucible, thermometer and beakers of different sizes were also used.

Chemicals and reagents

$Zn(NO_3)_2.6H_2O$ (98%, BDH Chemicals Ltd, England), $TiCl_4$ (98%, BDH Chemicals Ltd, England) and $Fe(NO_3)_3.9H_2O$ (98%, BDH Chemicals Ltd, England) were used along with NH_4OH (25%, Abron Chemicals), PEG (Aldrich) solution and ethanol (96%, Abron Chemicals) were used as solvents for synthesis of the nanocomposite.

Experimental procedure

Synthesis of nano sized M/M/M mixed oxide sorbent

Synthesis of nanocomposites was performed according to the procedure reported by (Dong *et al.,* 2006) as follows. A total of ten nanocomposites of zinc-titanium-iron oxides were prepared by gel evaporation method using precursors $Fe(NO_3)_3.9H_2O$, $Zn(NO_3)_3.6H_2O$, and $TiCl_4$, by varying the content of iron and titanium and using zinc as a host. Ammonium hydroxide, NH_4OH, was used for precipitation and ethyl alcohol was employed to wash the precipitate. For this synthesis, appropriate amounts of $Zn(NO_3)_3.6H_2O$, $TiCl_4$ and $Fe(NO_3)_3.9H_2O$ were used as salt precursors, starting with the pure zinc oxide at one end, continuing with pure titanium oxide and terminating with pure iron oxide at the other end. Aqueous solutions of precursor salts were mixed and stirred for 30 minutes along with slow addition of NH_4OH solution till pH was raised to 7 at which precipitation occurs. Stirring was continued for another 30 minutes, after which the precipitate was aged for 24 h. After drying for 1 hr at 90°C, the content was vacuum filtered and the precipitate was calcined in three stages: Stage I: 30 min at 250°C, stage II: 30 min at 600°C and stage III: 1 h at 800°C. Calcinations were carried out to avoid thermal shock to samples. The resulted powders were subjected to characterization through which three composites and the pure zinc oxide were selected according to their crystallographic information to use with bioadsorbents for the removal of toxic heavy metals from effluents. The as synthesized ten nanocomposites were designated as shown in Table 1.

Table 1. Designation of the as-synthesized powders.

Sample Name	Experimental Condition
C1	100% Zn
C2	80% Zn and 20% Ti
C3	70% Zn and 30% Ti
C4	60% Zn and 40% Ti
C5	80% Zn and 20% Fe
C6	70% Zn and 30% Fe
C7	60% Zn and 40% Fe
C8	80% Zn, 10% Ti and 10% Fe
C9	70% Zn, 15% Ti and 15% Fe
C10	60% Zn, 20% Ti and 20% Fe

Impregnation of the Nanocomposites

The synthesized Fe_2O_3-ZnO-TiO_2 ternary mixed nanocomposites in different molar ratios, well dried and powdered, were mixed with the bioadsorbent by impregnation method. In this regard, 0.1 M nano sized Ti-Zn-Fe ternary mixed oxides were mixed with the boiadsorbent by impregnating *Egg* and *Peanut Shells* with Iron nitrate, Zinc nitrate and Tin dioxide aqueous solution. The resulting mixtures having different percentage of precursors [$Fe(NO_3)_3.9H_2O$, $Zn(NO_3)_3.9H_2O$and TiO_2] in aqueous solution of ammonia were left undisturbed for 4 h to enhance formation of a gel, then dried at 110°C in an oven over night and further calcined at 350°C for 3 h and at 500°C. The synthesised nanocomposites were impregnated with bioadsorbent (*Egg* and *Peanut Shell* powders).

Characterization of the as synthesized nanocomposites

In order to investigate various properties of the synthesized nanocomposites, different characterization techniques were used. X-ray diffraction is a convenient method for determining the mean size of nano crystallites in nano crystalline bulk materials. It is an indispensable method for materials characterization and quality control. Ten series of as-synthesized powders were examined by XRD and then, 4 of them

were selected based on the nano size. As it has been used elsewhere (Patterson, 1939) the average crystalline size was estimated using Debye Scherer equation.

$$D = \frac{K\lambda}{\beta \cos\theta} \quad (1)$$

Where: D is crystallite size in nm, K is the shape factor constant usually 0.9, β is the full width at half maximum (FWHM) in radians of 2θ, λ is the wave length of the X-ray and θ is the Bragg's angle.

The absorption spectra of as-synthesized nanocomposite were measured by uv-visible spectroscopy. Aqueous suspensions of the samples were used for the uv absorption studies. The band edge of each nanocomposite was determined from the spectrum with maximum absorption age wavelength of maxiumum absorption. Band gap energy (E_g) of the as-synthesized powders was calculated using equation (2) (El-Kemary *et al.*, 2010).

$$E_g = \frac{1240\ eV}{\lambda_{max}} \quad (2)$$

Where, E_g is bandgap energy in electron volts and λ_{max} is wavelength (nm) corresponding to absorption edge. Elemental compositions of the nanocomposites were analyzed through energy dispersive spectroscopy (EDX). The EDX spectra have been used to confirm the existence of the major components in the as-synthesized nanocomposites. Scanning electron microscopy (SEM) was used to observe the morphological features of the selected nanopowders.

Batch adsorption studies

Batch mode adsorption studies for individual metal ions were carried out using 250 mL erlenmeyer flask. The effects of different parameters such as adsorbate concentration, adsorbent dose, agitation time and pH were studied. The erlenmeyer flasks were pretreated with the respective adsorbate for 24 h to avoid adsorption of the adsorbate on the container walls. Standard solutions of the metal ions were mixed with the *Egg* and *Peanut Shells* and agitated at different agitation rate on a mechanical shaker. This was carried out by varying the metal ion concentrations, pH and the mass of *Egg* and *Peanut Shells* used for adsorption. Finally, the resulting suspension of each of the metal ions was filtered using a Whatman No.1 filter paper and the filtrate was analyzed for the corresponding metal ion concentration. Removal efficiency was finally calculated by using the relationship (Sulak and Yatmaz, 2012).

$$\%\ Adsorption = \frac{(C_o - C_e)}{C_o} \times 100 \quad (3)$$

Where C_o and C_e are the concentrations of adsorbent initially and at equilibrium time t in mg/L, respectively, and m is the dose of the adsorbent in mg and V is the volume of the reaction mixture in (L).

Adsorption isotherms

A. Freundlich isotherm model

The Freundlich model is commonly given by the non-linear equation(4) and the Freundlich isotherm in its linear form is represented by equation (5) (Freundlich, 1906).

$$q_e = K_f C_e^{1/n} \quad (4)$$

$$\log q_e = \log K_f + \frac{1}{n}\log C_e \quad (5)$$

Where q_e is the amount of metal ion adsorbed per unit weight of the sorbent (mg/g), K_f is a measure of adsorption capacity and $1/n$ is the adsorption intensity. The Freundlich isotherm constants $1/n$ and K_f can

be calculated from the slope and intercept of the plot log q_e vs log C_e. The values of $1/n$ lying in between 0 and 1, and values of n lying in between 1 and 10 indicate the conditions favorable for adsorption. The intercept of the line, K_f, is roughly indicator of the adsorption capacity and the slope is an indication of adsorption effectiveness (Cooney *et al.*, 1998).

B. Langmuir isotherm model

The Langmuir isotherm in its linear form is represented by equation (6) Langmuir (1918)

$$\frac{C_e}{q_e} = \frac{1}{Q_o b} + \frac{C_e}{Q_o} \tag{6}$$

Where Q_o is the amount of adsorbate at complete monolayer coverage (mg/g) and gives the maximum sorption capacity of sorbent and b (L/mg) is the Langmuir isotherm constant that is related to the energy of adsorption. The Langmuir constants, Q_o and b, can be calculated from the slope and intercept of the plot C_e/q_e *versus* C_e, respectively. The feasibility of a Langmuir isotherm can be expressed in terms of a dimensionless constant separation factor, R_L (Weber and Chakkravorti, 1974), which is expressed as:

$$R_L = \frac{1}{1 + b C_o} \tag{7}$$

Adsorption kinetics

The adsorption rate constant for copper adsorption was calculated from the slope of the linear plot of t/q_t versus t. The pseudo-first order and pseudo-second order adsorption models were used to study the adsorption kinetics. The pseudo-first order adsorption kinetic model is given by equation (8). Whereas the kinetic analysis of metal ions were also studied based on reaction kinetics of pseudo second order mechanism using the lagergren rate equation as shown in equation (9, 10, 11 and 12) (Ho and McKay, 1998). Kinetics studies and dynamic continuous-flow investigations, offering information on the rate of the sorption metal uptake, together with the hydrodynamic parameters, are very important for biosorption process design (Volesky and Holan, 1995). First-order rate expression of Lagergren considers that the rate of occupation of biosorption sites is proportional to the number of unoccupied sites. The pseudo-first order adsorption kinetic model (Ho and McKay, 1998) is given as:

$$\log(q_e - q_t) = \log q_e - \frac{k_1}{2.303} t \tag{8}$$

Where q_e and q_t are the amount of metals adsorbed (mg/g) at equilibrium and at any time t (min), respectively. The adsorption rate constant k_1 was determined from the slope of the linear plot of log (q_e - q_t) versus t. Pseudo-second order equation is based on the assumption that the biosorption follows a second order mechanism and occupation rate of adsorption site is proportional to the square of the number of unoccupied sites and is represented by the following equations.

$$\frac{dq_t}{dt} = k_2(q_e - q_t) \tag{9}$$

$$\frac{d(q_e - q_t)}{(q_e - q_t)^2} = -k_2 dt \tag{10}$$

The integrated form at boundary conditions (t = 0 to t = t) and q_t = 0 to q_t = q_t gives:

$$\frac{1}{q_e - q_t} = \frac{1}{q_e} + k_2 t \tag{11}$$

$$\frac{t}{q_t} = \frac{1}{k_2 q_e^{\,2}} + \frac{1}{q_e} t \qquad (12)$$

Where q_t and q_e are amount of metals adsorbed at a time t and at equilibrium (mg/g) respectively, k_2 is the rate constant (g mg^{-1} min^{-1}), t is the stirring time (min). k_2 is ($slope^2$/intercept) can be determined from plotting t/qt against t based on above equation and the value of q_e is 1/slope. The larger the value of k_2, the slower the adsorption rate.

Figure 1. Egg (left) and Peanut shells (right) collected from HU.

3. Results and Discussion

Characterization of the adsorbent

XRD analysis

X-ray diffraction is a convenient method for determining the mean size of nano crystallites in nano crystalline bulk materials. It is an indispensable method for materials characterization and quality control. Ten series of as-synthesized powders were examined by XRD and out of these four of them were selected based on the nano size and used for all experiments in this work

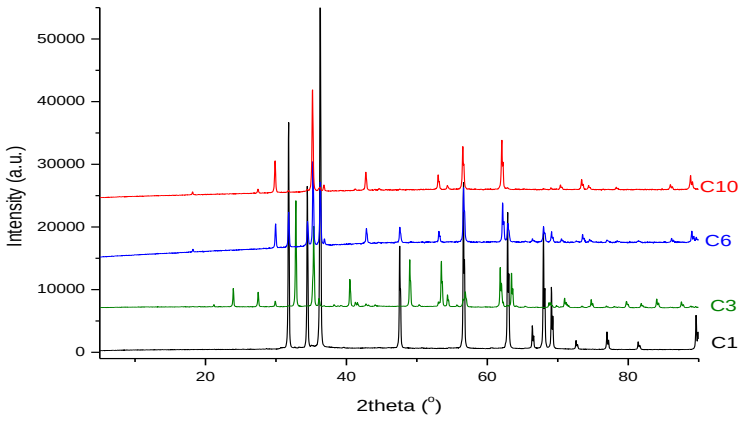


Figure 2. XRD pattern of as-synthesized nanocomposites.

The diffiraction peaks of all the powders are shown in Figure 2. The results show distinct peaks with their corresponding 2θ and β values (given in units of degree and radians, respectively) which accounts for the crystalline nature of all the as-synthesized powders. All diffraction peaks can be readily indexed to

tetragonal ZnO nanoparticles. Using equation (1), the average crystallite sizes of the as synthesized nanocomposites were calculated and given in Table 2.

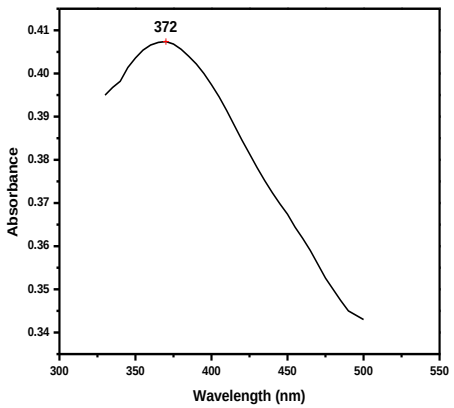
Table 2. Crystal size of as-synthesized nanocomposites.

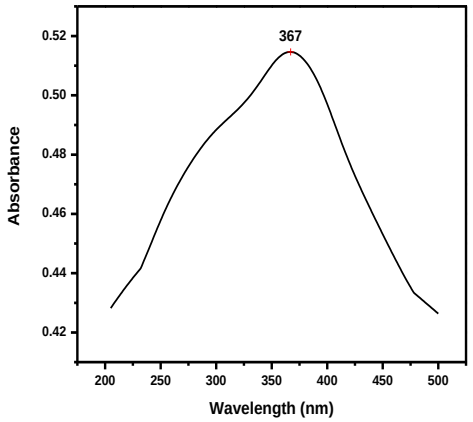
Nanocomposite	2θ (degree)	β (radians)	D (nm)
C1	35.611	0.00392	37.06
C3	35.760	0.00699	20.84
C6	35.646	0.00423	34.47
C10	35.466	0.00474	30.73

When the particle size decreases to the nanometer scale, no crystal lattice of a long-range order exists in the TiO_2 nanoparticle. From Table 2, all the as-synthesized powders fall in nano range and C1 for host, C3 for the different Ti ratios, C6 for the different Fe ratios and C10 for the different Ti/Fe ratios got the smallest crystalline size and hence with the greatest surface area. The lager surface area may benefit the contact between dye stuff and light, and can absorb larger numbers of dye stuff as well as increase photo activities. The smaller particle size for the mixed oxide could be attributed to an increase in the thermal stability and the resistance to sintering caused by the doped oxide. Based on this fact C1, C3, C6 and C10 are selected and subjected for further study.

UV-Vis absorption spectra analysis

Aqueous suspensions of the samples were used for the uv absorption studies. The absorption spectra of as-synthesized nanocomposite were measured by uv-visible spectroscopy. The band edge of each nanocomposite was determined from the spectrum with maximum absorption age wavelength of maxiumum absorption or from direct replotted spectra of $(\alpha\ h\nu)^{1/2}$ vs hv (commonly known as Tauc plot) by considering ZnO to be transition semiconductor and TiO_2/Fe_2O_3 to be an indirect semiconductor where α adsorption coefficient and v light frequency **(**Yunfang *et al.,* 2013).





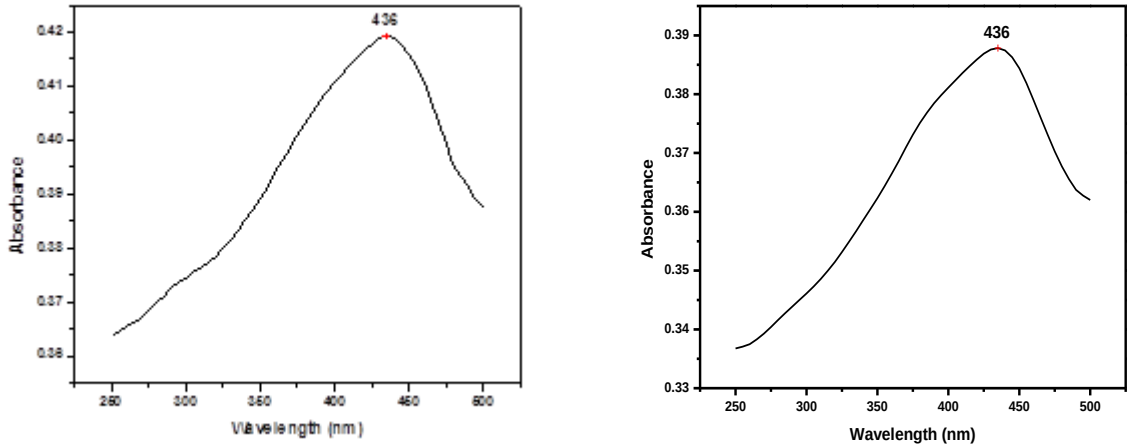


Figure 3. Absorption spectrum of C1, C3, C6 and C10 respectively.

As evident from Figure 3: the absorption edges of the binary oxides of C3, C6 and ternary oxide C10 shift remarkably to the visible range relative to the pure ZnO. This shift depends on the amount of TiO_2 and Fe_2O_3 incorporated. The observed absorptions are not attributed to the ZnO, TiO_2 or Fe_2O_3 band gap absorption but rather to the additional sub band gap absorptions. These sub band gaps absorption may arise from surface states of the ZnO-TiO_2, ZnO-Fe_2O_3 or ZnO-TiO_2-Fe_2O_3 materials. The surface states are surface localized electronic states within the material band gap, involving complex species such as dangling bonds, defects and atoms adsorbed on the surface (Laxmi and Chakrabarty, 2013). Band gap energy (E_g) of the as-synthesized powders was calculated using equation (2).

Table 3. Maximum wavelength and energy bandgap of the as–synthesized nanocomposites.

Samples	Maximum wavelength (nm)	Bandgap (E_g) (eV)
C1	367	3.38
C2	364	3.40
C3	372	3.33
C4	366	3.39
C5	387	3.20
C6	436	2.84
C7	397	3.12
C8	350	3.54
C9	397	3.12
C10	436	2.84

Critical comparison of the results in Table 2 depicts that the values obtained for the samples having Fe in their composition are remarkably small. The bandgap of pure ZnO and Fe_2O_3 are 3.2 eV and 2.1 eV, respectively whereas the calculated bandgap of ZnO-Fe_2O_3 mixed oxide varies from 2.84 eV to 3.2 eV. The energy level of Fe_2O_3 both for the valance band and conduction band correspond well within bandgap of ZnO. When the electrons are excited, most of the electron from the conduction band of ZnO can easily transfer to the conduction band of Fe_2O_3. This accounts for the reason why the bandgap decreased.

EDX spectra analysis

Elemental content was analyzed through energy dispersive spectroscopy. The EDX spectrum shown in Fig 4 has been used to confirm the existence of the major components in the as-synthesized powders.

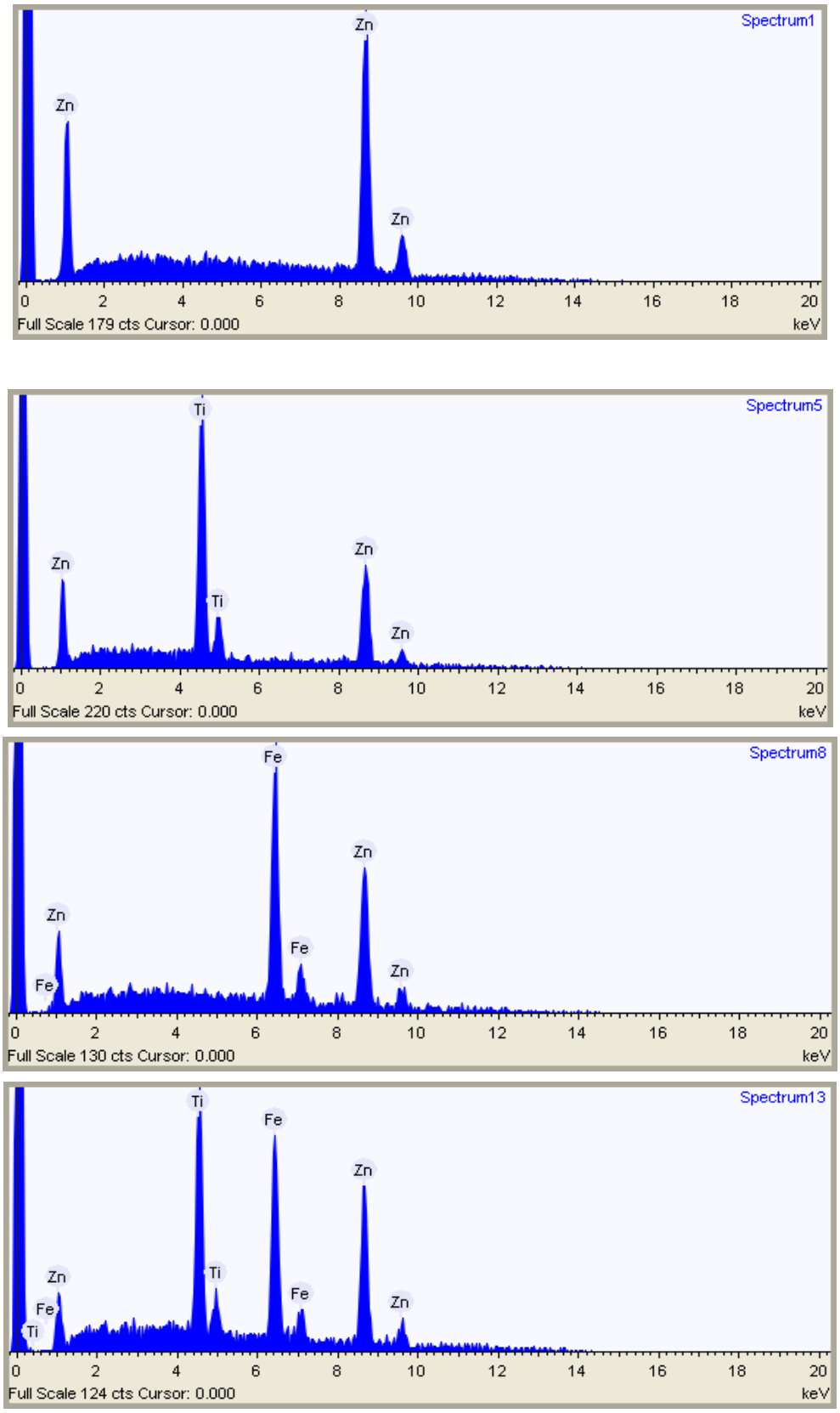


Figure 4. EDX spectrum of C1, C3, C6 and C10 respectively.

The analysis of the elements present in the selected samples was done by using the data present in the EDX spectra. It is depicted that the nano powders C1, C3, C6 and C10 are enriched with oxides of zinc only, zinc/titanium, zinc/iron and zinc/titanium/iron, respectively. Furthermore, the EDX spectrum reveals that zinc is the dominant component of the composite nano powders. Elemental content was also quantitatively analyzed through EDX. The atomic percentage of each element for the four selected as-synthesized powders is summarized in the Table 4.

Table 4. Atomic percentage of each element of the as-synthesized powders.

Sample Name	Zn%	Ti%	Fe%
C1	100	-	-
C3	41.5	58.5	
C6	49.3	-	50.7
C10	29.2	44.5	26.3

The EDX spectrum of C1 nanoparticles presented in Fig 4 exhibits well defined peaks for Zn and O elements, confirming the presence of ZnO nanoparticles. From the atomic percentage values, it is clear that C1 is richer with the elements Zn and O only. Whereas, The EDX spectra of C3 and C6 nanoparticles presented in Fig 4 show intense peaks for the elements Zn, Ti and O for C3 and Zn, Fe and O for C6, respectively confirming the presence of ZnO-TiO_2 nanocomposite for C3 and ZnO-Fe_2O_3 nanocomposite for C6 on the surface. The atomic percentage values for the elements also indicate that the nanoparticles are enriched only with the initial components which are having different sizes. Interestingly, the spectrum of C10 exhibits Zn, Ti, Fe and O peaks indicating the presence of ZnO, TiO_2 and Fe_2O_3 in the nanocomposite. The formation of ZnO-TiO_2-Fe_2O_3 nanocomposite was also confirmed from the atomic percentage values given in Table 4.

SEM analysis of the as-synthesized powders

Scanning electron microscopy (SEM) was used to observe the morphological features of the selected nanopowders. SEM images of ZnO, ZnO/TiO_2, ZnO/Fe_2O_3 and ZnO/TiO_2/Fe_2O_3 are presented in (Figure 5a - d). It is evident that, from the SEM analysis, the fabricated nanocomposite have different morphology. ZnO(a) particles has nanocrystals with irregularly shaped nanospheres and embedded nanoplates.

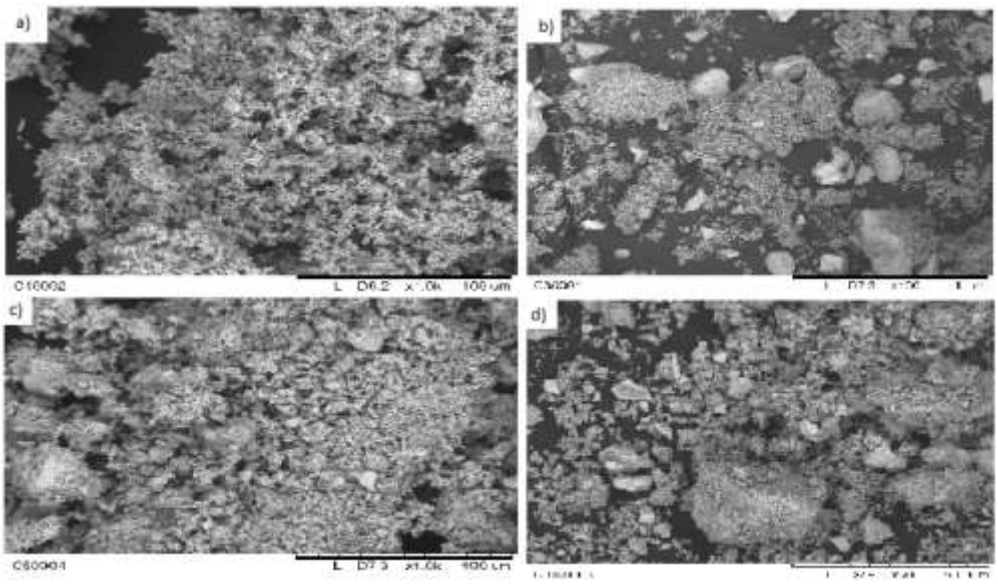


Figure 5. SEM spectrum of a) C3, b) C5, c) C6 and d) C10.

The SEM image of ZnO/TiO_2 (b) composite displays irregularly shaped nano particles which were aggregated in different clustering shapes and sizes with white snow-like flakes of ZnO mixed with TiO_2. The SEM images of ZnO/Fe_2O_3 (c) binary composite displays hexagonally shaped nanoparticles and nanospheres. Ternary metal oxides composite $ZnO/TiO_2/Fe_2O_3$(d) exhabits both nanoplates and irregularly shaped ZnO and hexagonal shapes of Fe_2O_3.

Batch adsorption studies

Batch adsorption experiments were conducted for the removal of Co, Cu, Cr and Ni ions from wastewater by $ZnO\text{-}TiO_2\text{-}Fe_2O_3$ impregnated with *Egg* and *Peanut* shells. The effects of different parameters such as adsorbate concentration, adsorbent dose, agitation time and pH and the removal efficiency of the $ZnO\text{-}TiO_2\text{-}Fe_2O_3$ impregnated with egg and peanut shells were studied.

1. Effect of agitation speed

Effect of agitation speed on adsorption of the four heavy metal ions (Cu,Co,Ni and Cr) were investigated (Figure 6) at each initial metal ion concentration of 20 mg/L and pH of 6.0 ± 0.01 and varying the agitation speed from 50 rpm to 200 rpm. It can be easily observed in Figure 5 that the adsorption efficiency of bio-sorbents impregnated with $ZnO\text{-}TiO_2\text{-}Fe_2O_3$ nanocomposite increases initially as the agitation speed increased from 50 rpm to 150 rpm. This is due to the fact that increasing agitation speed could improve the diffusion of solute towards the adsorbent surface. But, beyond this agitation speed the adsorption efficiency decreased because of more agitation speed causes more desorption of metal ions from the adsorption site.

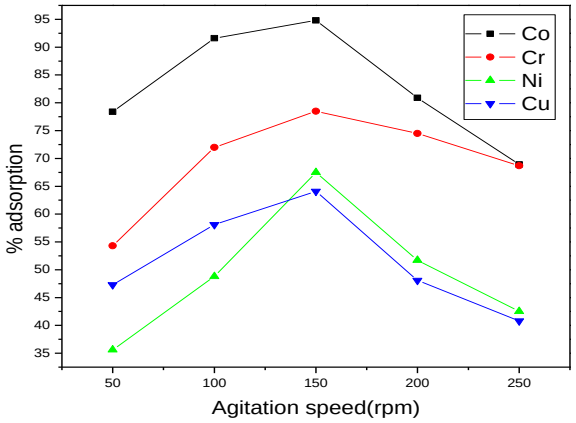


Figure 6. Effect of agitation speed on adsorption of metal ions(Co,Cu,Cr and Ni) at initial Concentartion of 20 mg/L, pH of 6.0 ± 0.01, dose 0.4 g and contact time 2 h.

2. Effect of pH

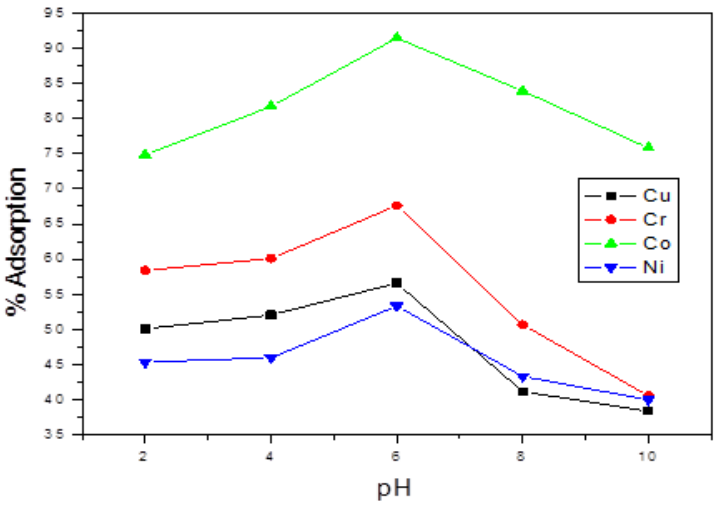


Figure 7. Effect of pH on adsorption of metal ions (Co, Cu, Cr and Ni) at initial concentartion of 20 mg/L, agitation speed of 150 rpm, dose 0.4 g and contact time 2 h.

The result in Figure 7 shows that the metal ions' uptake capacity is more favored in the acidic pH range of 6. The sorption of each metal ions increases with increased pH, reaching maximum at 6.0, and then decreases with further increase in pH due to the the surface of bioadsorbents impregnated with ZnO-TiO_2-Fe_2O_3 nanocomposite becomes positively charged which makes a repulsion against the metal ion. Therefore, the extent of metala ion dsorption on the bioadsorbents is governed by the pH.

Effect of contact time

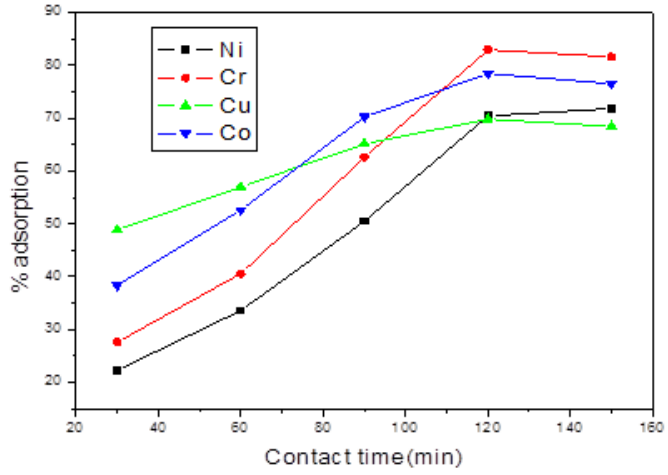


Figure 8**.** Effect of pH contact time at initial metal ion (Co, Cu, Cr and Ni) concentartion of 20 mg/L, agitation speed of 150 rpm, pH of 6.0 ± 0.01, dose 0.4 g.

It can be seen in Figure 8 that, initially the rate of each metal ion adsorption was found high during the first 120 minutes of contact time where 80% of the equilibrium adsorbed amount took place by the adsorbent. Beyond that, the rate decreases with time, as the liquid phase concentration decreases and the time to reach equilibrium seems shorter as the concentration becomes lower and the later stage slow adsorption is for the gradual uptake of each metal ion at the inner surface.

Effect of dose

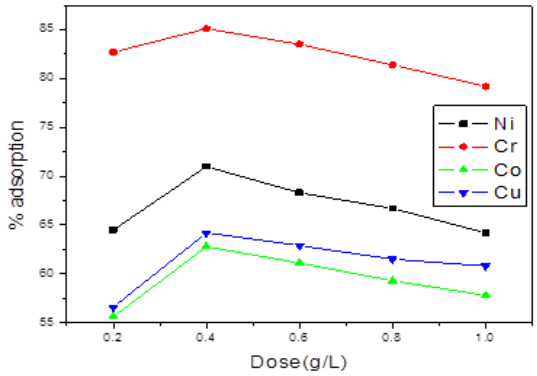


Figure 9. Effect of dose at initial metal ion(Co,Cu,Cr and Ni) concentartion of 20 mg/L, agitation speed of 150 rpm, pH of 6.0 ± 0.01, and contact time 2h.

The effect of adsorbent dose on removal efficiency of each metal ion was studied by varying mass of the adsorbent ranging from 0.2, 0.4, 0.6, 0.8 and 1 g at a constant initial metal ion concentration of 20 mg/L. The result in Figure 9 shows that the adsorption efficiency was significantly increased with dose up to adsorbent dose of 0.4 g; however, no significant change was observed beyond this dose under the experimental conditions used. Therefore, the increase in adsorption with increase particle concentration is a direct consequence of a great amount of available binding site for each metal ion. At the low adsorbent dose, all types of sites are entirely exposed and the adsorption on the surface is saturated faster showing a higher adsorption efficency. But, at higher adsorbent dose, the availability of high energy sites decreases with large fraction of lower energy sites occupied resulting lower adsorption capacity.

Adsorption isotherms

Freundlich adsorption isotherm

Freundlich isotherm is an empirical equation that encompasses the heterogeneity of sites and the exponential distribution of sites and their energy. The experimental data for the Freundlich parameters along with correlation coefficients were obtained by plotting log (q_e) *vs* log (C_e) as in Figure 10. The result of the Freundlich isotherm model showed that the experimental data well fitted to the model with a correlation coefficient (R^2 = 0.9969-0.9994). A straight line was obtained with a slope of 1/n(0.248, 0.240, 0.241, 0.231) and intercepts log K_f(1.60182, 1.63834, 1.5816, 1.7099) for Cu Ni, Cr, and Co respectively. The low value of 1/n (less than 1) for all the four metal ions indicateed the favorable condition of the adsorption process.

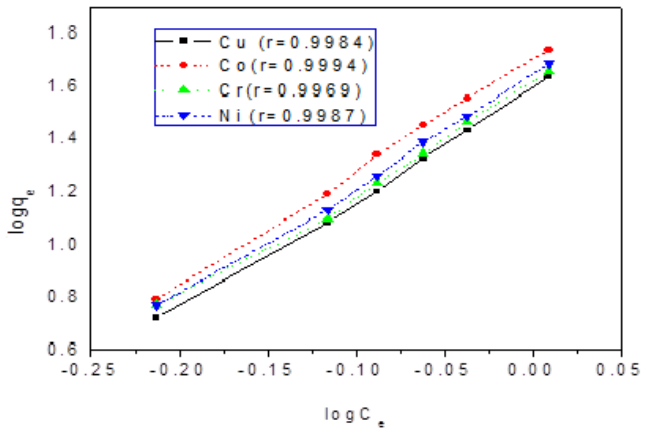


Figure 10. Linearized Freundlich adsorption isotherm for Co, Cr, Ni and Cu metal ions.

Langmuir adsorption isotherm

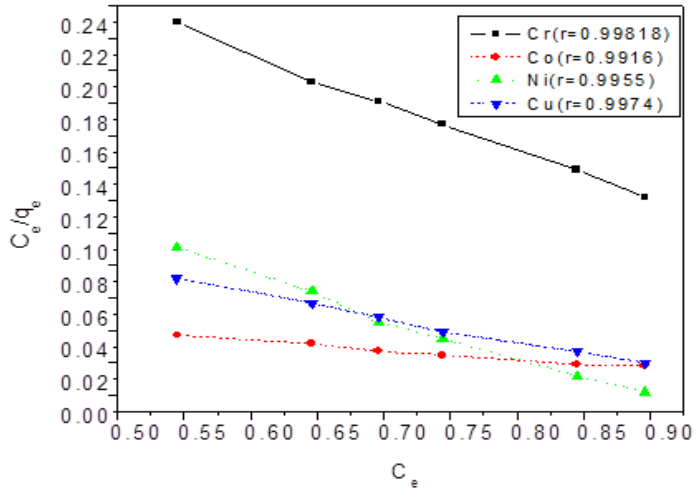


Figure 11. Linearized Langmuir adsorption isotherm for Co, Cr, Ni and Cu metal ions.

Table 5. Data for Langmuir adsorption isotherm.

Parametrs	Cu	Ni	Cr	Co
b	6.715	4.41	2.563	1.48
R_L	0.014	0.022	0.037	0.063

The Langmuir isotherm in its linear form is represented by equation (6) and the feasibility of a Langmuir isotherm can be expressed in terms of a dimensionless constant separation factor (R_L) (**7**). The constant b related to adsorption intensity was 1.48, 2.563, 4.41 and 6.715 L/mg for Co, Cr, Ni and Cu ion respectively. The R_L values in the range of (0.014-0.063) lying between 0 and 1 indicate the conditions are favorable for adsorption.

Table 6. Isotherm parameters for adsorption of metal ions onto bioadsorbents.

Isotherm model	Metal ions	Estimated isotherm parameters		
		1/n	K_f	R^2
Freundlich	Cu	0.248	1.60182	0.9984
	Ni	0.240	1.63834	0.9987
	Cr	0.241	1.5816	0.9969
	Co	0.231	1.7099	0.9994
Langmuir		q_e	*b*	R^2
	Cu	54.9541	6.715	0.9974
	Ni	48.5289	4.41	0.9955
	Cr	45.3942	2.563	0.9981
	Co	43.2514	1.48	0.9916

Adsorption kinetics

Adsorption kinetics was studied for copper ion with an initial concentration of 20 mg/L and an adsorbent dose of 0.4 g due to the highest adsorption capacity than nickel, chromim and cobalt metal ions. The residual copper concentration as a function of time is shown in the Fig 12. Accordingly, pseudo second-order reaction rate model gives a linear relationship adequately described the kinetics of sorption of copper ions with high correlation coefficient (R^2 = 0.99599) with rate

constant k_2 = 0.0533 as shown in Figure 13. The coefficient of correlation for the first-order-kinetic model was 0.99718 with rate constant of 3.79 x 10^{-9}. This study indicated that the pseudo-second-order model better represents the metal ion adsorption kinetics, suggesting that more of the adsorption process might follows second order chemisorptions process.

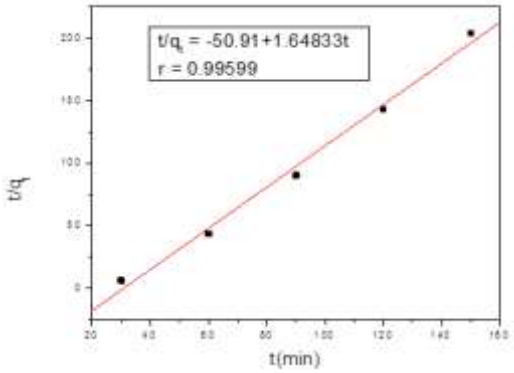


Figure 12: Pseudo first order plot of the adsorption kinetics with initial concentration of Co, 20 mg/L to adsorbent dose of 0.4 g and pH = 6.0 ± 0.01.

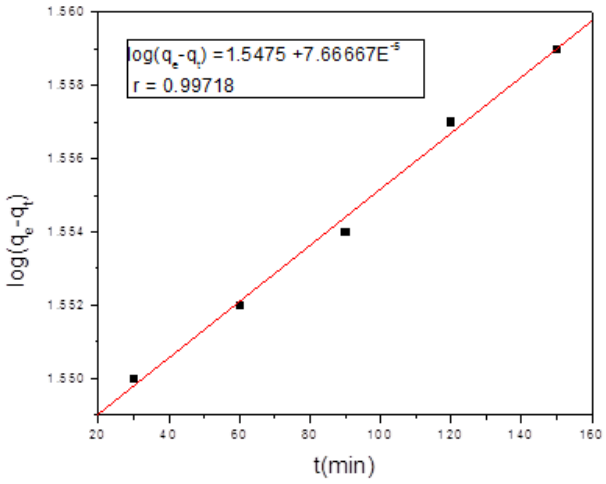


Figure 13. Pseudo second order plot of the adsorption kinetics with initial concentration of Co, 20 mg/L to adsorbent dose of 0.4 g and pH = 6.0 ± 0.01.

Adsorption of the tested heavy metals onto ZnO-TiO_2-Fe_2O_3 nanocomposite impregnated with egg and peanut shells and the concentrations of heavy metals untreated and treated samples from the students' main cafeteria, laboratory and staff residence effluents were presented in Table 7.

Table 7. Adsorption capacity of ZnO-TiO_2-Fe_2O_3 impregnated with Egg and Peanut shells for the removal of metal ions.

Samples	[M] ions untreated				[M] ions after treated by *Egg shell*				[M] ions after treated by *Peanut shell*			
	Cu	Ni	Co	Cr	Cu	Ni	Co	Cr	Cu	Ni	Co	Cr
M	0.123±0.001	0.017±0.001	0.025±0.001	0.016±0.002	0.003	0.007	0.008	0.008	0.004	0.006	0.008	0.009
R	0.127±0.	0.016±0.0	0.014±0.0	0.016±	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.0

	001	006	02	0.002	4	8	9	7	6	8	09	10
L	0.136±0.	0.101±0.0	0.125±0.0	0.129±0.	0.00	0.00	0.01	0.01	0.00	0.00	0.0	0.0
A	002	02	01	001	2	5	2	0	3	6	13	10
					% Removed							
					97.5	58.8	68.0	50.0	96.7	64.7		43.
M					6	2	0	0	5	1	68.00	75
					96.8	50.0	35.7	56.2	95.2	50.0		37.
R					5	0	1	5	8	0	35.71	50
					98.5	95.0	90.4	92.2	97.7	94.0		92.
LA					3	5	0	5	9	6	89.60	25

Copper concentration in the laboratory wastewater samples constituted the major portion of the total metal ions determined (0.136± 0.002) followed by Cr (0.129±0.001) and Co (0.125±0.001), while Ni(0.101±0.002) concentrations was the lowest. The concentration of copper in untreated effluent was found to be 0.136 ± 0.002 and in treated sample was 0.002; which means 98.53% and 97.79 % of Cu ions from laboratory effluents were removed by egg and peanut shells respectively. Removal efficiency of the bioadsorbents was finally calculated by using equation (3). Therefore, the concentrations of all metals were weltreated and the equilibrium adsorption data were best represented by the Freundlich isotherm, indicating monolayer adsorption on a homogenous surface and the adsorption capacity by an egg shell which were found to be for Cu (97.56, 96.85 and 98.53%), Ni (58.82, 50.00 and 95.05%), Co (68.00, 35.71and 90.40%) and Cr (50.00, 56.25 and 92.25%) from Haramaya University students main cafeteria (M), staff residence effluents (R) and laboratory effluents (LA) respectively. On the other hand, peanut shell removed about Cu (96.75, 95.28 and 97.79%), Ni (64.71, 50.00 and 94.06%), Co (68.00, 35.71and 89.60%) and Cr (43.75, 37.50 and 92.25%) from Haramaya University students main cafeteria (M), staff residence effluents (R) and laboratory effluents (LA) respectively. The obtained results revealed that the egg and the peanut shells have good adsorption capacity and is effective for the removal of heavy metals from domestic effluent.

4. Conclusion

All the as-synthesized nanocomposites were characterized using X-ray diffraction through which four of them were selected based on their smallest size. In this study, the experimental data revealed that the suitability of the synthesised nanocomposite impregenated with natural byproducts *Egg* and *Peanut* shells for the removal of Co, Cr, Ni and Cu metal ions in aqueous solution through batch adsorption studies. The Langmuir and Freundlich isotherm models were well fitted and all the four metal ions indicates the favorable condition of the adsorption process and the pseudo-second order model was better represented the metal ion adsorption kinetics, suggesting that more of the adsorption process might follows second order chemisorptions process. The concentrations of all metals were weltreated and the equilibrium adsorption data were best represented by the Freundlich isotherm. The experimental data revealed that the *Egg* and the *Peanut* shells have good adsorption capacity and they are effective for the removal of heavy metals from domestic effluent.

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6. Assessment of Reuse, Recycle and Recoverable Potential of Haramaya University Solid Waste

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Abstract: A study was conducted to assess the reuse, recycle and recoverable potential of Haramaya University municipal solid waste. Generation rate, waste type and physicochemical analysis of municipal solid waste (MSW) were evaluated. Results of municipal solid waste analysis indicated that the total amount of municipal solid waste generation rate per day at Haramaya University is estimated to be 2608.56 kg/day. The per capital solid waste generation rate is estimated to be 0.134 Kg/cap/day. The three waste categories that contributed the greatest proportion of the total sorted waste at all sources are compostable organic matter (57.31%), papers (16.26%) and fines (10.98%) respectively. These three waste categories accounted for approximately 84.55% of the total waste sorted. The remaining 15.45% of the sorted wastes are plastic materials (5.82%), miscellaneous (4.45%), card boards (2.37%), metals (1.30%), glass (0.87%) and textiles (0.63%). Generally, therefore municipal solid waste generated in Haramaya University is predominantly made up of compostable matter. The particle size distribution of compostable organic matter is 42.76% (greater than 50 mm), 53.2% (between 10-50 mm) and 4.04% (less than 10 mm). From the result, it was observed that large proportion of compostable organic waste is found in particle size range of 10-50 mm. The physicochemical composition of selected compostable organic waste was compared with standard values suitable for composting process. Generally, from the result we conclude that the organic fraction of Haramaya university municipal solid waste is suitable for composting process. In addition to compostable materials, the study revealed that there has been a generation rate of potentially recyclable 169.45 tone/year papers and carton, 59.49 tone/year plastic material and 11.82 tone/year metals (can). These materials should be collected separately (source separation) and can also be a means of income generation to the institute.

Keywords: Municipal solid waste; Haramaya University; Reuse, Recycle and Recoverable potential; Waste generation rate

1. Introduction

Human activities generate waste materials that are often discarded because they are considered useless. These wastes are normally solid, and the word waste suggests that the material is useless and unwanted (Tchobanoglous *et al.*, 2002). The estimated quantity of municipal solid waste generated worldwide is 1.7 – 1.9 billion metric tons (UNEP, 2010). The quantity of solid waste generated has increased significantly and its characteristics have changed as a result of the change in the peoples' lifestyles due to rapid industrialization and urbanization. Rapid population growth and increase of economic activities combined with a lack of training in modern solid waste management practices complicate the efforts to improve the solid waste service (ISWA & UNEP, 2002).

Reducing the quantity of wastes that have to be handled, transported and disposed in a landfill could lead to two main results in a reduction of the institutional expenditure dedicated to waste management and an increase of the useful life of the sanitary landfill. Besides these benefits, a reduction in the amount of waste produced by institution would also have environmental and social benefits (WWF, 1991). Institutions can easily fashion out their own mini-solid waste management systems within the large municipal solid waste management system framework. With such systems in place in institutions, resource recovery and waste recycling can more easily and effectively be incorporated, reducing the pressure on solid waste disposal sites. In addition, colleges and universities have the moral and ethical obligation to act responsibly towards the environment; they would be expected to be leaders in the movement for environmental protection. Specifically, it would be expected that universities would drive the efforts towards responsible waste management. It would set an example to the students and the community besides cost reduction for the management of waste.

Waste management programs in higher education institutions in industrialized countries began more than 20 years ago and vary from voluntary and local efforts to institutionalize programs (Armijo *et al*., 2003). Some of the higher education initiatives focused on recycling and waste reduction have been very successful. Recycling programs are one of the most popular environmental initiatives; in the USA 80% of the colleges and universities have institutionalized waste programs (Allen, 1999).

The type of decision making that leads to adequate solid waste management requires a sound understanding of the composition and the processes that determine the generation of waste. Special attention should be paid to the waste generation sources since the characteristics and composition of the waste differ according to their source (Tchobanoglous *et. al*., 1996). Considering this, waste management programs based on the knowledge of the waste composition would be more successful than the ambitious programs copied from somewhere else (USEPA, 1994). For this reason, when proposing waste management strategies these must be based on the reality of the generating source, thus, it is important to know the characteristics of the waste.

But, In Ethiopian Universities little or no study has been done regarding waste characterization and quantification for further analysis of recyclable and recoverable potential of wastes. No reliable data were recorded on solid waste characteristics and generation rate within the campuses of Haramaya University. Therefore, the primary aim of this paper is to reduce the gap between the need for this type of study and to explore the reuse, recycle and recovery potential of solid waste as a means of reducing HU municipal solid waste volume with a relative look at the utilization of resources.

1.1. Statements of the Problem

The collection and disposal of garbage is a problem that everyone facesworldwide. With increasing world population growth, concerns related to waste management continue to grow. Ethiopia is one of the countries which have fastest population growth rates in the world. Haramaya University is not different from many small cities of Ethiopia. The university is experiencing increases in student and staff population. It has residential with dormitory facilities for regular students and a number of modem houses for academic staff and their families.

Large amount of solid wastes is generated in the campuses of Haramaya University. But, there are no well-designed system/programs to manage the generation, collection and disposal of solid wastes. Some of the combustible wastes like paper, cardboard and garden trimmings are collected and improperly burned. These activities adversely affect human health and the environment. In addition to combustion, major proportion of the generated wastes are collected and dumped in the uncontrolled land fill. Uncontrolled dumping in landfills may cause serious threats to soil, underground water and threaten human health directly or indirectly. These risks can be reduced considerably by reducing the amount of waste that is dumped or left uncollected. The reduction of waste in the overall waste management system will be achieved by the practice of reusing, recycling and recovering of the waste. Therefore, the purpose

of this study is to identify and examine the possibility of reuse, recycle and recovery potential of Haramaya University compound solid waste as a solid waste management option and as income generation.

Therefore, the main objective of this study is to assess the reuse, recycle and recoverable potential of Haramaya University municipal solid waste and propose appropriate management systems. In this investigation, the generation rate, types and composition of HU compound solid waste and the existing HU solid waste management system and organizational structure is also evaluated. Besides, possible alternatives municipal solid waste management methods based on the characteristics of the waste is recommend.

2. Materials and Methods

Measurement sites

Measurements of wastes were carried out at students' halls of residence, offices, library, student cafeteria, student lounges, staff lounges, staff residence, laboratories and class rooms. The selected measurement places were the ones that were believed to represent major and typical sources of waste. This was in line with the need to get a representative spectrum of sources and types of solid wastes from the institution.

Sample size determination

The mathematical formula developed by Cochran was used to determine sample size (n) with the desired degree of precision for general population (Cochran, 1977). In this case population variable (P) is house unit variable, and is given as:

$$n = \frac{NZ^2PQ}{d^2(N-1)+Z^2PQ} \quad \text{.....} \quad \text{.....1}$$

Where n = sample size of housing units, P = residential houses, Q = non-residential houses (offices, class rooms, etc.) = 1-P, N = total number of housing units, Z= standardized normal variable and its value that corresponds to 95 % confidence interval equals 1.96 and d = allowable error (0.05).

According to data obtained from Haramaya University, there are about 2500 housing units (N): out of these around 80 % (P) are of residential (staff residence and student dormitories) and the rest 20 % (Q) is for non-residential (class rooms, offices, laboratories, library, shop, student lounge, cafes, and stuff lunge).

$$n = \frac{NZ^2PQ}{d^2(N-1)+Z^2PQ}$$

$$n = \frac{4762x(1.96)^2x0.72x0.28}{0.05^2x(4762-1)+1.96^2x0.72x0.28} = 297$$

Therefore n = 297 is the minimum sample size for reliable results.

Sampling techniques

Stratified and random sampling techniques were employed to select the houses for the study. Prior to sample collection for the analysis, preliminary site visits were made to assess the esthetic quality of the study area, to establish a basis for evaluating how study facts and figures correlate with visual evidence on the ground, to observe the physical nature of the solid wastes in dust bins at different localities of the

university and to categorize the site which were selected for sample collection. Based on the above investigation, the sites in the university were categorized into four major groups.

Group I: -Classrooms, offices, shops, laboratories and libraries (**non-residential houses):** Solid waste samples were taken from 83 non-residential houses

Group II: -Student cafeteria, student lounge, and staff lunge (nonresidential houses).

Solid waste measurement was done from student cafeteria and stuff lunge. Relatively, huge amount of solid waste generated from this group and difficult to take sample waste for generation rate study. Because of this, all generated solid waste was measured at the source without sampling.

Group III: - Staff residence (**residential houses).**

Waste sample collection fromstaff residence was done at 38 out of 517 houses, representing 7.35% of total number of stuff households. The choice of sample households was not the interest in mind because the status of houses and socio-economic differences were almost similar.

Group IV: - Students dormitories (**residential houses).**

Out of 2921 dormitories, 200 of them were taken as a sample. This represents 6.84% of total number of student residence.

Waste collection

Plastic bags were used for group one (classrooms, offices, shops, laboratories and libraries)**,** group three (stuff residence) and group four (student dormitories) sample collection. For group two (stuff lunge and cafes) solid waste generation measurement was conducted at the source without sampling.

Figure 1. Waste generation measurement from lunge and cafeteria.

Figure 2. Sample wastes collection from group one, group three and group four.

Persons in each surveyed group were instructed to use the plastic bags properly. The plastic bags were collected every morning according to the work plan with replacement of plastic bags with the same color and the same code number for the next day collection. The collected plastic bags were identified with their respective code, weighed and recorded by their corresponding code numbers. This was done for eight days; however, the waste collected on the first day of the survey was disregarded assuming that it was composite of waste stored for more than one day's solid waste generated.

Waste categorization

The samples were sorted out and different materials were separated by hand sorting. Then the measurement of each type of available material was done by weighing. The weight of each category of waste was recorded in a database. The weight percentage for each category was calculated by the following equation:

$$PS = \frac{PL}{PT} X100 \qquad \ldots\ldots 2$$

Where PS = the category percentage, PL = the amount of category in kg, and PT = the total weight of sample in kg.

The target waste categories include: - compostable organic matter (kitchen waste, khat, leaves and grasses), plastics, paper, metals, glass, textiles, fines (ash, dust etc), miscellaneous (wood, discarded hardware, discarded shoes, and other footwear, dry cells, batteries etc.).

Density

The density of samples was determined by weighing the wet sample and measuring the volume occupied by the loose sample in a container of known dimensions. Therefore, density of each sample was computed by the following formula:

$$\rho_b = \frac{(W_T - W_b)}{V_W} (Kgm^{-3}) \qquad \ldots\ldots 3$$

V_W = volume of the waste in the bin.

Particle size measurement

After recording the total weight and volume of waste components, each component of waste was sorted out by its particle size with wire meshes of sizes 50 mm and 10 mm.

Laboratory analytical procedures

Proximate analysis

Proximate analysis is the important step in the evaluation of combustion properties of the municipal solid wastes. The main aim was to determine ash, volatile matters, and fixed carbon and moisture contents of the municipal solid wastes. Samples of municipal solid waste (compostable organic matter, cardboard, textiles and paper) was collected in polyethylene bags and transported to the laboratory. The other waste components were excluded due to lack of capacity of the laboratory to conduct the analysis. The samples were subjected to standards test methods of proximate analysis according to ASTM standards (ASTM, 1988).

Moisture content

The percent moisture of the MSW samples was determined by drying the samples in an oven at 105°C for 1 hour. The percent moisture content (MC) was calculated as a percentage loss in weight before and after drying.

$$\%\ \text{Moisture content} = [(\text{Wet Weight} - \text{Dry Weight})/\text{Wet weight}] \times 100\% \quad \ldots\ldots 4$$

Volatile matter

The volatile matter content (VM) was determined by the method of ignition of the sample at 950°C. The triplicate samples of MSW material used in the moisture content determination were weighed and placed in a muffle furnace for 7 minutes at 950°C. After combustion, the samples were weighed to determine the ash dry weight, with volatile solids being the difference between the dried solids and ash weight over dried sample weight according to the following equation.

$$\%VM = \frac{(Weight\ of\ dry\ sample - Ash\ weight)}{Dry\ sample\ weight} \times 100\% \quad \ldots\ldots 5$$

Ash and fixed carbon

Ash content of waste is the non-combustible residue left after waste is burnt, which is represents the natural substances after carbon, oxygen, sulfur and water. Analysis include of dried the samples at 750°C for 1 hour.

$$\%Ash(wt\%\ dry\ basis) = \frac{weight\ of\ residue\ after\ ignition}{weight\ of\ dry\ solid\ waste} X100 \quad \ldots\ldots 6$$

Fixed carbon defined by carbon found in the material which is left after volatile test. Fixed carbon is determined by removing the mass of volatile from the original mass of the sample.

$$Fixed\ carbon\ (Wt\ \%\ wet\ basis) = 100 - (Wt\ \%\ moisture\ content + \%\ Wt\ Ash + Wt\ \%\ volatile\ matter \quad \ldots\ldots 7$$

Calorific value

The amount of heating value was determined by using mathematical models (Kathiravale, 2003).

$$HHV = 356.047VM - 118.035FC - 5600.613 \quad \text{Dry (w\%) KJ/Kg} \qquad \text{.....8}$$

Where: HHV = High Heat Value, VM = %volatile matter and FC = % fixed carbon

Physicochemical analysis

The pH value of a solution is the negative logarithm of hydrogen ion concentration. Sample pH was measured potntiometrically in the supernatant suspension of a 1:2.5 solid sample-liquid mixtures by using a pH meter. Total N were determined by using the Kjeldahl procedure. Heavy metals were determined by using flame atomic absorption spectrophotometer (FAAS).

3. Result and Discussion

3.1. Existing Solid Waste Management Practices in Haramaya University (HU)

The major sources of HU solid waste were students' halls of residence, offices, student cafeteria, student lounge, cafes, staff lounge, staff residence, laboratories, library and class rooms. The wastes from these sources constitute mainly compostable organic waste, including food leftovers. Food leftovers from student cafeteria, student lounge, cafes and staff lounge used as feed for animals which were found in H.U. animal farm. The remainders of the organic waste were collected and disposed into open landfills. Bottles and cans from student lounge collected separately and stored for sell. Paper and cardboard waste generated from office, classrooms and libraries burned in different sites in the campuses. For onsite storage plastic containers were used for each building. Totally, there were more than 500 sweepers and 1 collector crew (17 persons) in the university.

Figure 3.Tractor-trailer used for wast collection and transportation.

A tractor-trailer was used for collection and transportation of wasts from on-site storage to the disposal site. The capacity of the tractor-trailer used to collect and transport the waste was about 2 x 4 x 0.5 m. Collection frequencies of solid waste were twice per day from cafeteria at main campus and once per day at station and *Gendaje* campuses. Solid wastes from staff residences were collected three times per week.

Figure 4. Organizational structure of solid waste management in HU.

Waste generation

The waste generation rate from Group I (classrooms, offices, shops, laboratories and libraries), Group II (student cafeterias, student lounges, resource center and staff lunges), Group III (Staff residences), and Group IV (Students dormitories) was estimated 353.07 kg/day, 943.12kg/day, 806.06kg/day and 506.31kg/day, respectively. Generally, the total amount of municipal solid waste generated from HU was estimated to be 2608.56 kg/day.

According to the data obtained from HU, the number of graduate students, undergraduate students, administrative staffs and academic staffs on duty were 1613, 14036, 2894 and 857 respectively. Therefore, the total contributing population number in HU was 19400 (HU facts and figure 2015). Based on population data and total amount of generated municipal solid waste; per capital amounts of municipal solid waste generated on a daily basis was calculated.

Total weight of solid waste generated per day = 2608.56

The total contributing population = 19400

Per capital solid waste generation rate $= \frac{2608.56}{19400}$ =0.134Kg/cap/day

Generally, the estimated solid waste generation rate in HU main campus was 0.13 Kg/cap/day. This value fall within the range (0.094 to 0.156 kg/capita/day) reported for household & academic institutional solid waste generation rate in Khulna metropolitan city (Riyad et al, 2015), waste generation rate for Addis

Ababa city (0.127 kg/cap/day up to 0.579 kg/cap/day) for the low, middle and high income level group (Nicolas et al., 2010) and the generation rate in rural areas (Less than 0.15 kg/cap/day) reported for Asian countries(APO, 2007). But it was less than the range (0.4 kg/cap/day to 0.6 kg/cap/day) reported for low-income countries (Cointreau, 1982).

Bulk density

Measurement of solid waste density is a very important parameter for planning, scheduling and designing of municipal solid waste management infrastructure. Accordingly, the bulk densities of solid wastes from different sources at HU were determined.

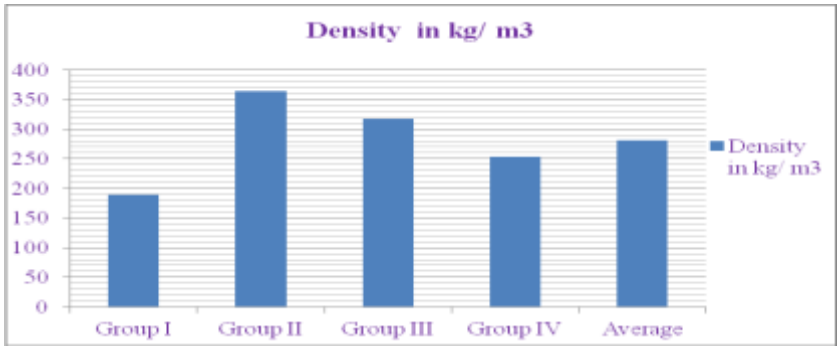

Figure 5: Mixed municipal solid waste bulk density from different sources.

The highest bulk density of the waste was recorded from group II waste stream (364.42 kg m^{-3}). For a similar argument, the second highest bulk density was recorded from group III waste stream (317.48 kg m^{-3}). These values fall within the range (250-500 kg m^{-3}) reported for low-income countries (Cointreau, 1982). The larger average bulk density of group III and group II waste stream could be due to the occurrence of high moisture containing waste like vegetables, fruit peels , Khat waste and fine materials (dust, ash, stones etc).The smallest bulk density was recorded from group I (189.82 kg m^{-3}) and group IV (253.73 kg m^{-3}) waste streams. This could be due to the occurrence of higher fraction of paper waste (Fig.8). Generally, the average bulk density MSW generated from HU is 281.36 kg m^{-3}. This value falls within the range reported for Addis Ababa city (205 - 370 kg m^{-3}) and low-income countries (250-500 kg m3) (Yami Birke, 1999 and Cointreau, 1982).

Waste characterization

The study was employed with nine categories. These included paper, plastic, compostable organic matter (kitchen waste, Khat, leaves, grasses), cardboard, metals, glass, textiles, miscellaneous (wood, rubber, discarded shoes, dry cells, batteries etc.) and fines (dust, ash, stones etc).

A. Waste Composition by Source

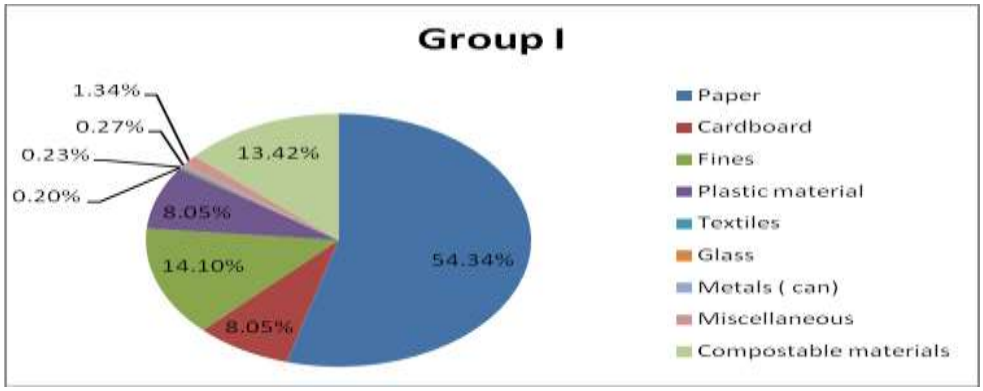

Figure 6. Group I (classrooms, offices, shops, laboratories and libraries) solid waste composition.

The waste generated from group one waste stream was dominated by paper waste. It can be seen that the highest portion by weight is paper (54.34%) followed by fines (14.10%), compostable organic matter (13.42%), cardboard (8.05%), plastics (8.05) and miscellaneous (1.34%).

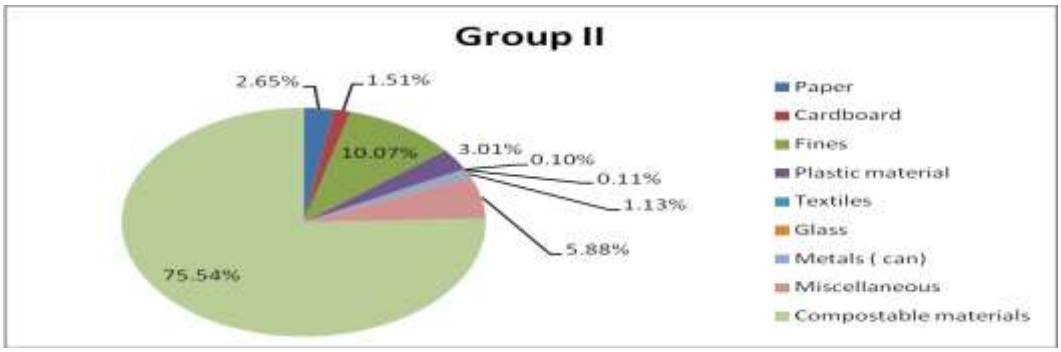

Figure 7. Group II (student cafeteria, student lounge and staff lunge) solid waste composition.

The waste category with the greatest mean composition from Group-II waste stream was compostable organic matter. It accounts 75.54% of the sorted waste. Significantly, more than half of this material was kitchen wastes (fruit piles) with the remaining material consisting of leaves and grasses waste. The next highest contributing category was fines (10.07%). The remaining waste was made up of miscellaneous (5.88%), plastics (3.01%), paper (2.65%), cardboard (1.51%), metals (1.13%), glass (0.11%), and textile (0.1%).

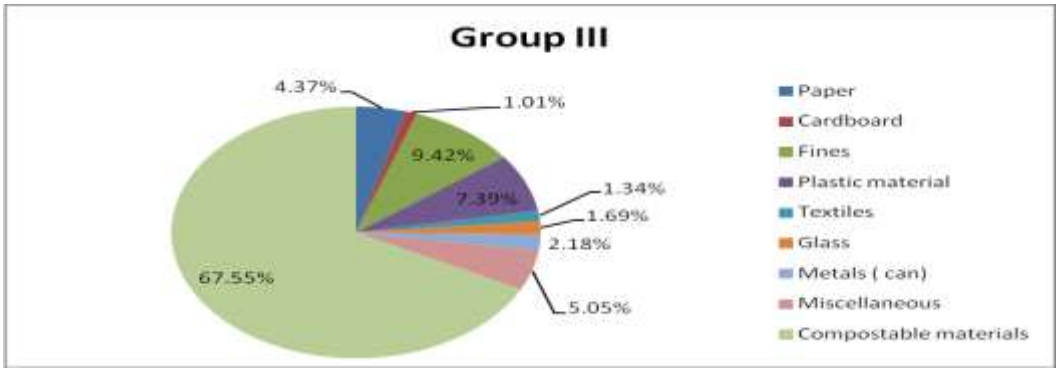

Figure 8. Group III (Staff residence) solid waste composition.

Compostable organic matter about 67.55% sorted from staff residence, most of which was kitchen and Khat waste. The second and third highest waste categories were fines and plastics account 9.42% and 7.39%, respectively. The category contributing the fourth largest quantity to the staff residential waste stream was miscellaneous, account 5.05% of the waste stream. Paper waste and metals waste account 4.37% and 2.18% respectively. The remaining waste categories (textile, glass,) each made up less than 1.7% of the staff residential waste stream.

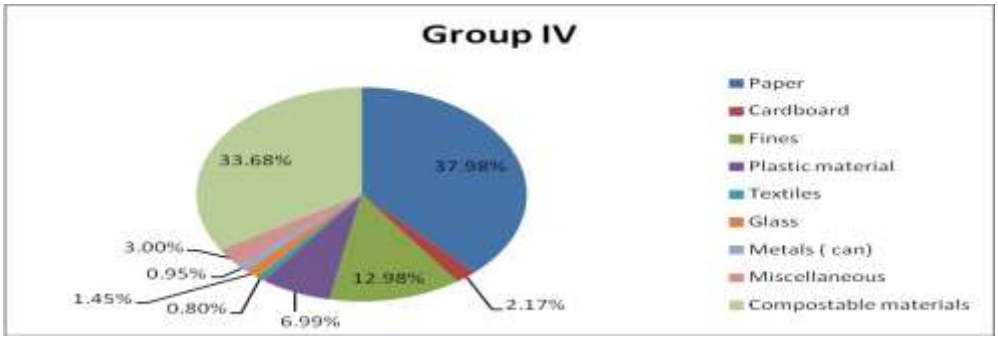

Figure 2: Group IV (Students dormitories) solid waste composition.

The waste category contributing the greatest quantity was paper waste, accounting for 37.98% of the student residential waste stream. The second highest waste category was compostable materials (kitchen waste, Khat, leaves, grasses etc) 33.68%. And fines (dust, Ash, stones etc) and plastics account for 12.98% and 6.99%, respectively.

B. Average waste composition from all sources

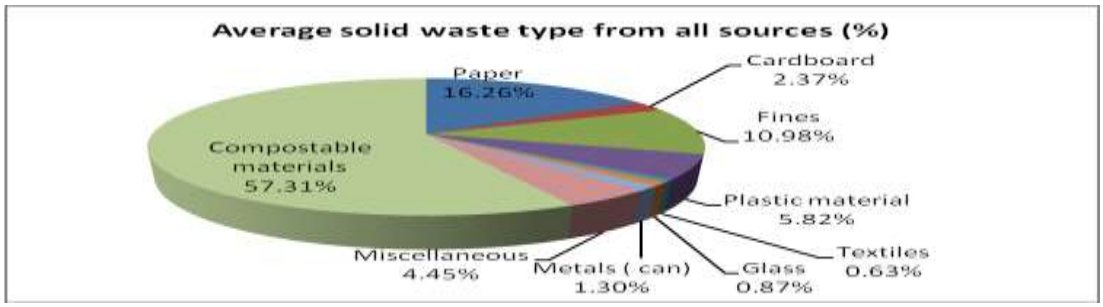

Figure 30. Average waste composition from all sources.

The three waste categories contributing the greatest proportion of the total sorted waste from all sources are, in descending order: compostable organic matter, paper and fines contributing mean compositions of approximately 57.31%, 16.26% and 10.98%, respectively. Combined, these three waste categories account for approximately 84.55% of the total waste sorted. The remaining 15.45% of the sorted waste was plastic materials (5.82%), miscellaneous (4.45%), cardboard (2.37%), metals (1.30%), glass (0.87%) and textiles (0.63%). Generally, municipal solid waste generated in HU is predominantly made up of compostable organic matter. The large organic content (Compostable organic matter) indicates that the necessity of recycling of the organic wastes into valuable resources like compost (bio fertilizer). Although institute of higher education are somewhat limited by the composting facilities of their region, Universities are often more likely to have composting programs than the cities in which they are located (Chung and Finnigan, 2004). Higher education institution like HU demonstrates the leadership role that other institutions can play in improving local municipal organics management and overall environmental stewardship.

Particle size measurement

Wastes are divided into three particle size categories. These are particle size larger than 50 mm, between 10 - 50 mm and less than 10 mm as indicated in Figure 40.

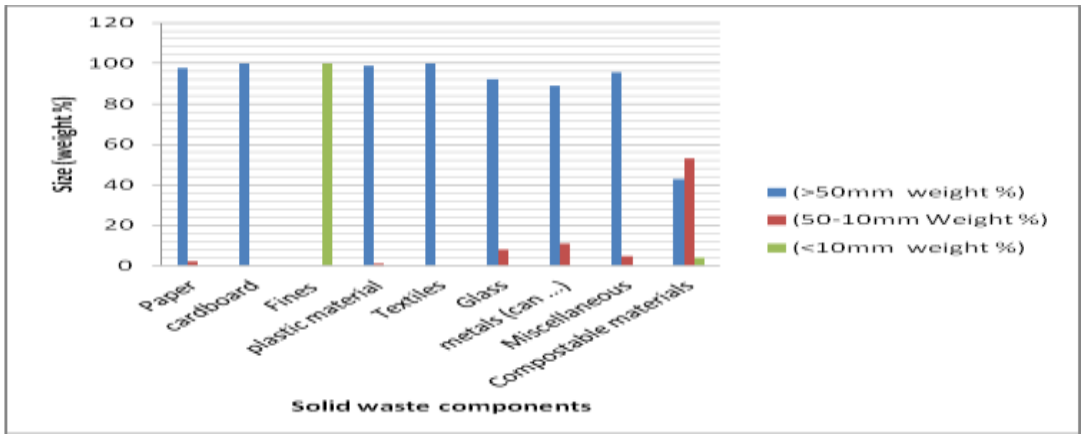

Figure 50. Particle size distribution.

The particle size distribution of compostable organic matter was 42.76% (greater than 50 mm), 53.2% (between 10-50 mm) and 4.04% (less than 10 mm). From the result, it can be observed that large proportion compostable organic waste was found in particle size of 10-50 mm range. This is because compostable organic matter generated from cafeterias and lounges was dominated by fruit peel which has medium particle size. On the other hand the organic waste generated from stuff and student residence has significant amount of khat waste which has larger particle size (>50mm).

Elemental (Ultimate) analysis

The physicochemical composition of selected compostable organic waste from HU MSW was compared with those of the standard values of MSW suitable for composting processes. As a result, the average values of moisture content, carbon and C/N of selected compostable organic waste from HU MSW were slightly greater than the standard values (MC <50, carbon 30-40%, C/N 25-50:1) (Gautam, S., et al., 2010). But, the average values of pH and nitrogen content falls within the range of standard values suitable for composting process (pH 5.5-8.0 and nitrogen content >0.6%). The average values of heavy metals were small in amount. Generally, from the result, it can conclude that the organic fraction of MSW is suitable for composting process.

Proximate analysis and heating value

Based on laboratory analysis result, the moisture content of compostable materials, paper, cardboard, textiles and plastic wastes were estimated to be 55.2%, 12.4%, 3.6%, 14.2% and 0.4 %, respectively. Volatile matter is the portion of the waste which is converted into the gas before and during combustion. Fixed carbon is the carbon remaining after all volatile matter that evolves from the particles. Combustible materials such as paper, cardboard and plastic are the components with high percentage of volatile matter which has 74.20%, 85.00% and 92.19%, respectively, which mean that higher volatile matter the higher the reactivity of the materials. The advantage of high volatile matter and low fixed carbon is rapid burning of a solid waste residue (Barmina *et al.*, 2012). The lower percentage of ash content was referred to quantity of plastic waste (1.40%). A solid waste which has low ash content does not hinder, the combustion of char, and allow easier diffusion of oxygen into the char (Mohd H. and Ridzma Z., 2012).

Energy content of MSW is usually described in terms of high heat value (HHV), lower calorific value (LHV), net heating value or gross heating value. In this study, the higher heat value (HHV) of the composite HU solid waste (compostable, paper, cardboard, textiles & plastic) was determined by using mathematical model based on the proximate analysis result. According to Kathiravale (2003), proximate analysis model gives an accurate estimation of the calorific values of the samples. The estimated HHV for HU composite MSW was 22877.68KJ/kg, this value was slightly lower than the HHV (23000kJ/kg) estimated for Malaysia (Amin K. and Go Su Y., 2011), but it is greater than the estimated energy content of typical residential MSW (11782 kJ/kg). This could be due to the occurrence of higher fraction of materials which has high calorific values, such as paper, cardboard, plastics and textile etc.

Potential for reuse, recycling and recovering

Recycling, reusing and recovery of wastes are important component of integrated solid waste management as it decreases the load of waste going to the dumping site or for incineration. In HU, there is no provision for recycling or recovery of the municipal solid waste until now. Thus, the data obtained from this study can be used to identify the potential of the reuse, recycling and recoverable materials from HU MSW and to implement the appropriate management system in the campus.

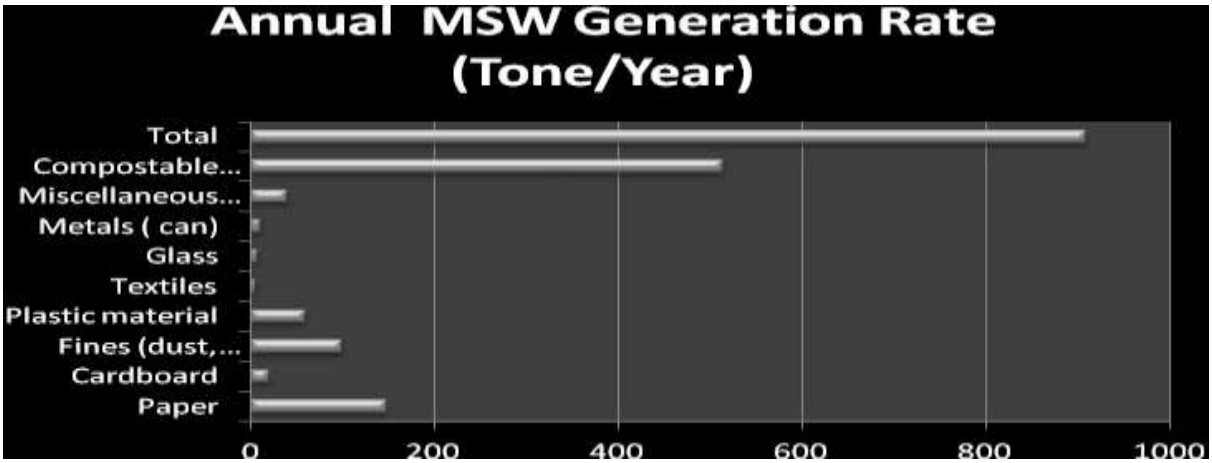

Figure 61: Annual MSW generation rate at HU (ton/year).

For better waste management in HU, the study on amount of waste generation and composition is very important to select a proper management system. As discussed on the above figure (Fig. 11) most of the generated wastes decomposable and organic. The organic solid waste (compostable materials) constituted on average the highest (57.31%) fraction of the total municipal solid waste generated from HU main campus. Organic waste is mainly composed of kitchen wastes such as vegetables, fruits, food remains, etc and not much garden wastes (grass and leaves) were observed. The annual generation rate of compostable materials (organic MSW) estimated to be 546.08 tone/ year (table 1). This result confirms there is a huge compostable material resource potential from HU MSW. Moreover, the physicochemical composition analysis and particle size measurement results also shown us the suitability organic MSW (Compostable materials) for composting process. Composting of recoverable organic waste might be the most appropriate option among others for municipal solid waste management in HU since it is low cost and simple. Furthermore, composting has many environmental benefits: improving soil health and structure; reducing the consumption of fertilizers and pesticides. In addition to compostable materials, the study revealed that there has been a generation rate of potentially recyclable 177.48 tone/year papers and carton, 55.43 tone/year plastic material and 12.42 tone/year metals (can) (table 1).

The estimated calorific value of HU composite MSW was around 22877.68KJ/kg. The heating value of coal is about 37 – 40 MJ/kg (Heylighen F., 2001), this means that the energy that can be produced by one kilogram of coal can be produced by two kilograms of municipal solid waste. In general, the high average amount of heating value (about 22877.68KJ/kg) and proximate analysis result of HU composite MSW shows the feasibility of designing the waste to energy plant such as incineration. But, incinerators require a large capital investment with little economic return. Moreover, the plants need a constant supply of waste for maintaining optimal combustion (Connett and Connett, 1994). For that reason, the combustible waste generation rate at HU may not be sufficient (not equally distributed trough out the year) for constant supply to the incinerator.

Table 1. Recommended solid waste management options for HU MSW.

Solid Waste Type		Recommended solid waste management options for HU MSW			
		Estimated Annual Generation Rate (Tone/Year)	Recyclable and/Reusable material	Recoverable material (For compost)	Land fill disposal
Paper and Cardboard		177.48	✓		
Fines (dust, Ash, stones etc)		104.61			✓
Plastic material		55.43	✓		
Textiles		6.03	✓		
Glass		8.33	✓		
Metals (can)		12.42	✓		
Miscellaneous	Wood, rubber and discarded shoes	42.40	✓		
	Dry cells, batteries, bones etc				✓
Compostable materials (kitchen waste, leaves and grasses)		546.08		✓	
Total		952.78	302.09	546.08	147.01

4. Conclusions and Recommendations

4.1. Conclusions

According to the field survey and discussion with concerned bodies, the current solid waste management practice is not satisfactory. Food leftovers from student cafeteria, student lounge, student cafe and staff lounge were used as feed for animals, which are found in HU animal farm, but other organic wastes were collected and disposed in to open (uncontrolled) landfills. Paper and cardboard waste generated from office, classrooms and libraries were burned in different places in the campuses which have significant environmental implications. Generally, waste minimization techniques such as recycling, composting, energy recovery practices were very limited in the HU. The study revealed that, the total amount of MSW generation rate per day at HU is estimated to be 2608.56 kg/day. The per capital solid waste generation rate was estimated to be 0.134 Kg/cap/day. The generation rate was lower compared to the generation rate of low income countries. But, because of large population number in HU, huge amount of MSW is generated and disposed inappropriately.

The compostable organic matter represented a significant proportion of the total HU MSW. It accounts for about 57.31%, of the total MSW production. The remaining wastes were paper (16.26%), fines (10.98%), plastic materials (5.82%), miscellaneous (4.45%), cardboard (2.37%), metals (1.30%), glass (0.87%) and textiles (0.63%). Therefore, municipal solid waste generated in H.U was predominantly made up of compostable organic matter. The large organic content (compostable organic matter) indicates the necessity of recycling of the organic wastes into valuable resources like compost (organic fertilizer). The

particle size distribution of compostable organic matter was 42.76% (greater than 50mm), 53.2% (between 10-50 mm) and 4.04% (less than 10 mm). From the result, it can be observed that large proportion of compostable organic waste was found in particle size of 10-50 mm range. So, only small portion of compostable material may require size reduction (chopping) during compost heap preparation (composting process). The results clearly demonstrated that the physicochemical composition of selected compostable material from MSW was suitable for composting process. In general, considering the climatic conditions and other factors, composting of selected organic matter is suited for HU municipal solid waste and windrow composting could be the best option to deal with the huge volume of compostable waste. This type of recovery should be adapted to recycle the organic residues as waste management option and income generation. In addition to compostable materials, the study revealed that there has been a generation rate of potentially recyclable 169.45 tone/year papers and carton, 59.49 tone/year plastic material and 11.82 tone/year metals (can). These materials should be collected separately (source separation) and can also be a means of income generation to the institute.

4.2. Recommendations

The current solid waste management practices should be improved based on the principles of integrated solid waste management. Composting of recoverable organic waste is appropriate option for municipal solid waste management in HU. Proximate analysis result of HU composite MSW shows the feasibility to design the waste to energy plant such as incineration. But, incinerators require a large capital investment with little economic return. Also, the plants need a constant supply of waste for maintaining optimal combustion. For these reasons, the combustible waste (compostable, paper, cardboard, textiles & plastic) generation rate at HU may not be sufficient for constant supply to the incinerator. Some wastes are simply not recyclable (like dust, ash, stones etc), because they eventually reach a point at which their intrinsic value is dissipated completely, so they no longer can be recovered, and recycling itself produces residuals. Accordingly, well designed (modern) sanitary landfill should be constructed at HU to manage these kinds of wastes.

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Theme IV

Human and Social Development

1. Digital Documentation and Contextual Analysis of Selected Oromo Children's Folklore (Riddles) in Haramaya and Chiro Districts

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Abstract: Being constructed from their cumulative cultural practices, the folkloric knowledge and experiences provide the community with massive and multifaceted educational and entertaining lessons while addressing issues of various social groups. Children folklore is one of these genres that serve as the bearer of moral values and education helpful for children's proper upbringing. They are inclusive of taxonomies of educational domains and ensure the proper growth and development of the children and make them active and creative citizens. In spite of various social dynamics and cultural shifts that may considerably affected the content , values and transmission of children's folklore. different Oromo clans have preserved such folk wisdom together with their arts and crafts as part of long-living traditions. This research was` aimed to document Oromo Children's folklore (riddles) together with their underlined and diverse human experiences, knowledge, artistic expression, creativities, philosophical thoughts, linguistic features and imaginations of the society. These themes fully elucidate the implicit, explicit and implied meanings of riddles as the genre deals with issues of children. The digital video and audio recordings, focus group discussions, interview and document analysis from published and unpublished sources were used in the process of data gathering and these data were qualitatively analyzed. The narrative text aligned with the video data recorded in the natural settings of the riddle helped to produce documentary film as summary of the project to be archived online. The essential Oromo concepts were used in *Qubee Afaan Oromoo* (Afan Oromo Script). The fundamental elements, social values, artistic thinking, experiences of the society, philosophical thoughts, linguistic features and other aspects employed in the riddles were critically examined. These themes are found to be the source of moral values and academies lessons which are reliable and relevant to shape and construct children as active and creative citizen.

Keywords: Children; Folklore; Documentation; Riddles; Values, Wisdom

1. Introduction

Folklore is the bearer of moral values and norms which are the main themes for both personal development and social transformation. Hence, folkloric experiences should be instilled in the children right from the very beginning at grassroots level where children should actively exercise human moral values as determinant factors for future generation. In fact, the source of human moral values is supposed to be originated from small ancestral groups and transmitted from generation to generation providing them with medium of learning (Nesbitin in Christian 1995:81).Through the investigation of such values, the community would be provided with sufficient knowledge and wisdom which assist them to perform meaningful roles in community's developments and an implication of real social transformation.

In spite of the stated facts, the lack of moral values is observed to affect the generation from actively engaging in many developmental activities. As Enoch (1995:80) commented, the moral social problem has become the topmost in the 20th century and by extension to 21st century unlike the former two centuries when the major problems were originated from authority and economy. , This idea is also shared by many critics and indigenous value adherents in the justification they forwarded specially regarding the bad situations of young generation as they are quite advocators of western traditions in many aspects discrediting their social values. As a result, there is great threat on the continuity of oral tradition. Folklore as the bearer of various societal values and ethical lessons, significantly solve the behavioral problems of the children and promote their personal and social developments. Therefore, the cultivation of values imbibed in children's folklore like riders shapes the children to be active, creative and logical thinker. The values encompassed in such folklore genres are helpful to regulate relationships among children, children and their reference groups and children's relationships with their parents. More importantly, such folk traditions serve the children as the foundation for their psychosocial, personal, cognitive developments and means of entertaining.

In the current time Oromo folkloric genres in general and children's folklore in particular are widely available but paradoxically scarcely performed by members of cultural community. Especially children's folklore (riddles) is the integral part of cognitive, affective and psychomotor skills' development of the children. They also serve as tools for teaching children about socialization from the grassroots. The gradual deterioration and immersion of Oromo folk traditions, however, have affected ways of innovating them and left behind the original oral tradition. Owing to the passive and reluctant nature of the contemporary young generation and devastating nature of globalizing forces, many oral traditions of the society also remain unknown publicly and do not usually serve the community in shaping, educating and guiding, passing values, enhancing creative thinking and training misbehaving of children. The problems seem to be aggravated by different social forces: urbanization, sense of modernization, universal religion etc. In reality, any knowledge is materialized from the society and serves up the society. Thus, an emphasis should be given to the analysis and proper documentation of Oromo children's folklore (riddles) whose status and current uses found to be eroding gradually.

Currently, the issues of children have become the major focuses as the children are taken as the societies' central nation building forces in the informative generation. They can determine the survival, progress and fate of upcoming generation. Thus, different oral traditions and folk knowledge in Oromo society are vital to address issues of children for different purposes. Oromo folk genres also remain unstudied except a few attempts made by anthropologists, art historians, and amateurs (Wirtu, V1-10, Gemechu, 1998, Temene, 2004, Adam, 2008, Wiirtuu Vol.11 where in children's folklore is treated in fragmented manner. Hence, their studies in real social context have got less attention and this could be a major problem for scholars within the field. Accompanied by the absence of proper documentation, the problems have limited the utilization of oral traditions among the children and the young generations among Oromo people. In same token, Sumner (1996:2) argues "… since the Oromo have no written literature or language, they were an ideal group for the study based on oral literature."

In Oromo society, there are different contexts in which issues of children are seriously taken into consideration. In the *Gadaa* system, the two primary consecutive age sets/ *gaam'oma* and *dabballooma*/deal with issues of children emphasizing their roles in the society. At these age groups, depending on children's level of maturity, several folkloric experiences can be related. At the age of (0-8 and 8-16), children enter into the active *Gadaa* age-set and included in *Gadaa* to exercise different duties and responsibilities invaluable for their proper growth and maturity. The *Gadaa* tradition enforced them to get trained in music and folk arts to acquire experiences (Alemayehu, 2009:57).They are assumed to learn good experiences and knowledge through adequate exposure to folkloric knowledge ultimately discharging certain roles in full social contexts.

Oromo society also considers children as prominent riches, and hence demands folkloric experiences to express their love, their happiness and to show their respect to them. Kedir (2009:3) tried to collect and

analyze some proverbs and songs that address issues of children in Arsi region and remarked there to be wide prevalence of various genres in Oromia region which are not studied partially or totally. Thus, the proper documentation of children folklore in different areas assists the proper growth and development children in various aspects: to nurture them, to make them keen observer, enthusiastic, skillful and active participants in speech events. In line with, this study promotes the practical significances and thoughts of the society on the potential significance of children related folklore, mainly riddles, in local and global setting. The study could create further awareness on issues of children from psychological, socio-cultural, cognitive and linguistic perspectives taking riddles as the major focus. The observation of poor status of the current documentation and studies on children folklore similarly insisted the proper documentation of Oromo children's folklore textually and digitally.

Objectives of the Study

In view of the above-mentioned ideas, the general objective of this research was to document selected Oromo children's folklore (riddles) using digital audio and video recorders in their contextual settings. The specific objectives were to:

- Classify riddles into their major constituents explaining them in line with social roles, duties and responsibilities of children in Oromo society;
- Demonstrate the socio-cultural significances and linguistic features of children's folklore in Oromo society;
- Describe the procedural performance of children's folklore (riddle) in line with the cognitive, psychomotor and affective development of children; and
- Explain the potential significances children's folklore by emphasizing the uses of riddles in educating and entertaining children.

2. Theoretical Framework

The functional theory identified by Dorsan (1963) has been used in the study. This theory is commonly used by anthropologists and ethnographers to describe the traditions of indigenous societies in various setting to use data for several applications (David, 1996:49). It helps to elaborate the importance of children's folklore in the immediate need in the family hood specially in examining the significances and values incorporated in children's folklore. Such functions like maintaining good relationship among children; create harmony between children and their families, and harmonizing children and the society at large can be demonstrated in terms of folkloric functions in full social context.

3. Methods and Procedures of the Study

3.1. Descriptions of Study Area

This research was directed towards the collection, classification and analysis of selected Oromo children's folklore (riddles) at different settings in Haramaya and Chiro Districts of East Haraghe and West Hararghe zones, respectively. The sites were selected on the basis of the possibilities to integrate both rural and urban traditions. It was also assumed to provide opportunities to exploit experiences of the people on the specific and general operations of children's folklore (riddles) due to the interactive nature of the society. Genealogically, majority of the ethnic background of the people in the two districts belong to *Ituu and Hubbaanaa* Oromo clans and their immediate branches are *Afran Qalloo*-the four *Qalloo* clans (Alaa, *Baabbilee, Daagaa* and *Oborraa*) and their religion is predominantly Islamic. Cash crop production, trading and animal rearing (to some extent) are the major economic activities of the area. Especially, the first two economic activities fused with *jimaa* ceremonies (*barcaa, ija banaa,* and *cabsii*) facilitate the

interaction among people and create a peculiar and strong social bond among the people. The *jimaa* ceremonies usually attract people who have similar jobs, views or who have been friendly from childhood. The ceremonies are vital in the secular and religious life of the people. In enhancing social relationship and harmony, the free and extremely open nature of the society and their strong participation in social engagements create various opportunities to use different conversations and hence folkloric experiences sharing among the group is very strong.

Haramaya and Chiro districts were purposely selected on the basis of their characteristic to manifest clans with different cultural practices and in terms of sharing some similarities with other Oromo clans of Hararghe Region. For obvious reason and by consensus, the more to move from the geographic center to the periphery is the more one can come across local clans with diverse culture and traditional practices which may get little scholarly attentions. Intuitively, the research area has been experiencing with traditions unique to their own locality which accelerate strong interaction among people through the stated ceremonies. As signified, various forms of *jimaa* ceremonies serve as gathering sites whereby different groups have the opportunities to exchange oral traditions worthwhile documenting. Though the indigenous oral traditions are persistently prevalent among the society of the area, they kept intact to the present due to socio-cultural, economic and ideological problems that stacked their transitions. The sampled population includes people who were experiencing mutual engagements, oral historians and artistic people of the community and skilled children in children folklore, all accessed through purposive and snowballing samples.

3.2. Sources of Data and Data Collection Tools

The research approach used is a qualitative ethnographic one encompassing a range of philosophies…and specific techniques including in-depth interviews, participant and non participant observations, focus group discussions, and document analysis. As Pearson (2005) identified such data is the core component in folkloric documentation and for the preservation of folk heritages in questions. Hence, the aim of ethnographic research is to "recognize speech genres and registers, to describe the context of speech events and to identify significant terms and expressions" (Bruna in Jost J. et al 2006:186). The study of folklore involves the direct observation, involvement and interpretation of speech genres, the description of physical and cultural environment as well as social realities under which folklore genres are performed. This kind of study is also widely explains the cosmological, social structural events and the description of human and non human elements to analyze different cultural units, community's knowledge, practices as well as their philosophical thoughts and cultural values.

The data for the research were gathered from community elders, village leaders, cultural think thanks, religious leaders (sheiks) and *Gadaa* experts and children. Attempts were also made to balance the number of participants based on their cultural knowledge and tradition of the local people through contact persons at various elicitations stages. Events were captured upon the performers (riddler-respondents) interaction in contextual settings. In each District Oromia Culture and Tourism Bureau, co-ordinations of the bottom offices were already made with the main offices in the hierarchy especially through collaborative folkloric research projects. So, the strong relationships and communication made with these experts and individual participants in different offices paved the way for easy access to data from the remote villages. Their concerns and advice provided opportunities for active communication with possible stakeholders. This consolidated strong intimacy between the researchers and member of the local community in the process of data collection.

Structured and non-structured interview, focus group discussion, observation, digital video and audio recorders, and text collection were employed as data gathering tools. Each tool helped get people's general feeling towards children's folklore, to understand the riddler-respondent interactions in series of field works and to get people's opinion and comments. Upon capturing the nature of interaction and communicative events upon discussion held among children(riddle players) and their parents (riddling facilitators), different sessions were held in natural and induced natural settings followed by elicitations

sessions. Contexts were provided in such a way that parents and children were made summoned at different setting to increase the degree of interactions. Observations were also helped to describe the type of performance, style of performance and their procedures as well as the existing norms.

To complement oral data, texts that the researchers collected during annual field trip for courses like 'Introduction to Folklore' and 'Oromo Poetry' were integrated into the data. The data were transcribed, classified, and analyzed using the method of 'content analyses'. In this method the contents of communication events are studied for their authenticity or meaning. It helps to make inferences about background, characteristics and effects of a communication objectively and systematically (Holsti in Steve, 2001). Approach to content analysis formulated by Harold (1972) can be expressed by six key questions:" who says what, to whom, why, to what extent and with what effect?" Accordingly, in this research who refers to the performer i.e. children, what refers to forms of folklore and the type of message, whom refers to the audience i.e. the narratees, why refers to the reason behind telling or using children folklore, to what extent tells as the degree of being importance, and what effect deals with the emotional feeling observed on individual after listening or using children folklore. The Corel Video editing soft ware was used in the process of editing the video to produce documentary film. The data collected using both digital audio and video recordings were captured for further annotation, translation, transcription and final analysis of the work.

3.3. Conceptualization of Children and their Roles

The concept of child and childhood vary from culture to culture. The American educators associate the concept to school children and all young people from kindergarten through 12th grade recognizing children's ascending levels of maturity (Tucker, 2009:19).Based on aspects of people's culture and its socialization effects, the concept varies in time and space (Hughe and J. Kroehler, 2009:84).For instance, during medieval time, nobody attempted to portray the concept of child as it was considered as small adult and expressed kinship (Tucker, 2009:19). From the Ariès's 'Centuries of Childhood' published in 1962, Tucker identified that children were portrait without adults and the common and a distinctive culture of childhood began as a child-centered social category. But in recent time, the concept of children is associated with schooling and works done in factory, mines and fields left to the adults (Hughe and J. Kroehler, 2009:84). In the current time, children are distinguished by displaying peoples' oriented response at very early age to adolescence contributing some things towards social life.

The issue of child and childhood is strongly related to socialization which is a lifelong course, continuing life long process to be considered as a change in the changing world (Hughe and J. Kroehler, 2009:84). In socialization, the writers described that life course begins with concept formation at childhood and continue through old age and till ultimate death. This varies with social arrangement around chronological age and can be distinguished in terms of three phases in the roles of socialization. The first one deals with behavior association with new role in which children acquainted themselves with adult's roles. The second one is learning the expectations of associated roles and shaping the roles in response to the new situations. The third one is individual move throughout their lives and entering roles as well as disengages and exiting from many roles. As pointed by Hughe and J. Kroehler, these three major roles exercised in the socialization process leads children towards achieving the final adults' roles.

According to cognitive anthropologist, childhood is identified both by cultural products and their intellectual development in fixed stages (Hicks and A. Gwynne, 1994:57-58). Thus, during the first stage of development or sensory motor stage (0-2 years), children gain motor controls and skills so as to learn about the reality by observing physical object, peoples and actions around them. During preoperational stage (2-7 years), they start to learn to speak and this determines their later ability to reason out. Again in the concrete operational stage (7-12 years), children gain the ability to understand abstract concepts. During formal operational stage (9-15 years), they refine their ability to reason logically and consistently. In view of cognitive anthropology, children achieve the same cognitive development by exercising different oral genres in line with their maturity levels.

From linguistic theory and cognitive psychology points of view, children undergo both linguistic competences- knowledge of language rules and performance- observable behavior right from the beginning of early telegraphic speech and proceeds to the stage of grammatical development of children (William, 1984:7). Particularly, the children form concepts about the world and the meaning which they feel stimulated to communicate. The cognitive factors determine both the meaning the children perceives and empressehow to make sense the linguistic systems. Again, from cross cultural perspectives, it is universally agreed that the childhood begins at birth though it is difficult to determine when it ends; this is still a question whether gender, class, race, religion or other factors play a role in determining when childhood ends. However, as it is set in the Oromo *Gadaa* system, among the 11 stages in which the active *Gadaa* members pass through, the first and the second age set: *gaam'omaa* (0-8 years) and *dabballoomaa* (8-16 years), clearly identified children by ages and their respective roles.

The social practices and their roles can also be well understood in the society which exercises certain cultural practices. Society and culture are highly interrelated and thus, the two concepts should be defined to determine children's roles. Society is defined as "a group of people who live within the same territory share common culture" and "culture refers to the social heritage of people those learned patterns of thinking, feeling, acting and that can be transmitted from one generation to the next generation" including both material and non- material culture (Hughel and J. Koehler, 2009:42).The relation between culture and society is that the society is the actors up on cultures to show some practices. Under this condition culture provides the meaning that enables human beings to interpret the experience giving their action and the society represents the networks of social relations that arise among people.

From cognitive anthropologists perspective that culture can be interpreted and explained by examining various categories by which human being organize their thinking. Since these categories order and classify thoughts, they affect the way in which individuals organize their experiences of the world(Hicks and J. Gwynne, 2007: 56). Cognitive anthropologist considers their specialty to be essential for understanding of culture. In this regard, from the views of cognitive anthropologist, Piaget examined children concepts of time, space, number of logic to discover whether their intellectual development occurred in a fixed stage (Hicks and J. Gwynne, 2007: 56). The findings of these writers show that starting from the sensory motor stage (from birth to 2 years) up to formal operational stage (12 to 15 years), children show different progressive development in which they consciously and subconsciously perform different roles.

Similarly, Hendry (2008:200) explained the system of age grade in which all men in the society including those who born in particular period of time are supported to be organized as member of particular age set. Through this age set system, the members share some sort of membership with their age mates through life moving gradually through age grades as they get older. Hendry demonstrated this taking Nandi and Maasai people who live in East Africa as an example. These people have seven age sets recruiting about 15 years respective to their roles. The age sets include young groups or small children who exercise free sexual access between the girls and the boys, warriors who is expected to get married and four group elders.

As a core point of anthropology, classification plays a great role. It is a system which is shared by members of particular society and it is fundamental characteristics which are acquired by children growing up to be member of that society (Hendry, 2008:220). Children constitute a distinctive age group that shares many traditions. This implies that classification is the base for socialization of a child, the conversion of biological being into social one in which the children shares a system of communication with the surrounding community. According to Sutton-Smith and others (1999:311) cultural category is seen form classification generated by members of a cultural group to describe themselves and it is the same as analytical category: form of classification generated by analyst for the purposes of comparison. For instance, according to the Oromo *Gadaa* System the age is categorized into 11 groups from early child hood *dabballoomaa* (0-8) to the late old age and time of retirement called *jaarsaa* (above 80 years old). The first *dabballooma* (0-8) and the second *gaam'omaa* (8-16) specify various roles which the children are expected to perform. These includes learning socialization and integrating to family, neighbors, lineage

and engaging in secular and religion training, being incorporated into the reference groups, explore folk traditions, etc. .

Children's Folklore and its Significances

Respective to their culture, the diverse forms of children's folklore belong to different societies are helpful for making children active and productive citizens. Children's folklore shape children's behavior, guide them, help them in manipulating language skills joyfully, learn the past and motivate them towards performing new and exciting things. Besides, children's folklore enriches public folklore which represents the depth and diversity of folk traditions. Specially, their contents are helpful for people to learn and understand various issues of children.

Children's folklore is one of the very oldest continuous traditions divided into the folklore of children and folklore for children (Utah, 2009: 61). The folklore of children refers to children's folklore performed by children for other children. They include materials forced upon children by parents and teachers. These include playground rhymes, games, and chants, counting-out rituals, taunts and insults which are included in school playground. The folklore for children is passed on from adults to children. These are nursery rhymes, bouncing or 'dandling' games, traditional fairy stories and family sayings told to children. This category of children's folklore is given more insight into parents and teachers' worldview than the worldview of children. As of Utah, the course dealing with folklore of children gives emphasis to "literature for children" rather than "literature of children".

In the field of children's folklore, Tucker (2009: vii) claims that the discovering of remarkable range of children's traditions help to demonstrate children's creativity enabling them to come up with new versions of old rhymes, songs, narratives, and other expressive forms. They also tend to preserve certain patterns that have pleased previous generations of young people. For instance, the collected and preserved legends and songs in certain time in the past may enable the current generation to learn the past traditions and their significances in the contemporary generations.

Apart from its aesthetic values, entertaining children, and passing some comic information, children's folklore enriches public folklore that represents the depth and diversity of folk traditions. It also gives much attention to the reflections of social and political change and connections between children's folklore and education. According to Tucker (2009:12) children's folklore carries multi-dimensional of purposes as indigenous art. Firstly, it is the means by which particular society expresses various forms of art belongs to their children and reliable indigenous wisdom. Secondly, it incorporates values and virtues that the society need to promote in the proper growth of children (teaching them, avoiding their misbehavior and respecting social norms and taboos). Thirdly, it restores the culture and traditions in real performance, educationally enjoyable and relevant in its content to be adapted to curriculum.

Classification of Children's Folklore

Classification of folklore genres is one of the integral parts in folklore studies. It helps to know the general subject matter of the genres, functions, general field categories, original sources, structure and styles. Classification also paves the way for further analysis of the genres. The major and common classifications in the studies of folklore are based on themes, functions, generic types and generic names which are complementary. Sutton-Smith and others (1999) and Trucker, 2009) classify children's folklore by generis types as game, songs, poem and rhyme, riddles, tales and legends, riddles joke and routines of victimization, rhymes, taunts and counter taunts, songs , cheers, games, pranks, narratives, rituals and martial culture. From the view of traditional cultural of Zambian community, Mulala (2009:2) classifies children folklore broadly as ceremonies folklore, traditional dances, songs, etc. These genres are emerged from all cultural issues and activities in which children actively engage as key players. In modern sense (Davey et al ,from Margrét,2011:32-34)described some forms with certain explanatory notes as important educational and entertaining forms of children's folklore used as games at school setting. These are mimic

songs, verbal game with a toy, tongue twisters, rowing games, card games with a rhythmic text, teasing songs, counting-out rhymes etc. According to elders in Chiro District, there is more than twenty such form of children's folklore in Chiro District. Generally, it is impossible to limit the counts of children's folklore as they dramatically vary in number and forms based on the diverse nature, culture, wisdom and language of the local communities.

Definitions, Meanings and Concepts of Riddles

The word 'riddle' is originated from old English word 'redan' meaning 'to guess', 'to interpret', and finally 'to seek solution' that help as the source of knowledge (Barnet et al, 1981:425). The Oxford Senior Dictionary also defined riddle as "question or statement designed to test imaginary or give amusement in finding its answer or meanings sometimes puzzling or mysterious". Riddle is also "a puzzling problem or question; an enigmatic, saying or speech statements or query phrased as to require ingenuity to discover its meaning" (Harry Shaw ,1972:324). As Cuddon (1979:574) stated "riddle is an ancient and universal form of literature, in common set form consisting of a puzzle question: the equivalent of a conundrum or an enigma". The above definitions of riddle communicate three central themes: the analyzing of problematic and mysterious speech genres, solving of problems logically and communicating the messages meaningfully. So, if children get exposed to the riddles, they develop various skills that enable them to be critical thinker and active participant in communicative events.

Riddle is one of the common and short forms of children folklore presented in opening and closing formula and problem solving activities as the major focus. This genre is supposed to be the earliest children's folklore with major intention to educate the community providing the youth with care and exposing the children to various lessons (Njoroge in Kenya, 1994:55). As the writer stated, different societies have different types of riddles. Of these, the major ones are simples and complex riddle, riddle songs, chain riddle, riddle analogous and riddle play. Whether simple, complex or other forms, the primary purposes of all forms of riddles are to develop the critical thinking, their linguistic and language skills, their logical thinking abilities and serve as sources of normative lessons for children. Riddles also help the children to expand their imagination and problem-solving abilities in the process of searching different expected answers to the riddling questions. To give the answer, specially the children enthusiastically undergo and discover the puzzle, imagine and touch up on incidents and events of the cosmic order before arriving at the final answers.

Objectives and Significances of Riddles

The main and most frequent purposes of riddle are related to achieve pedagogical lessons and leisure-time activities. As Sutton-Smith and others (1999:163) outlined in pedagogic riddling, the adults play the roles of teachers and the children play the roles of student through riddles. In the pedagogical aspect, children riddles are employed by parents to make their children curious and active listener who decipher the knowledge very quickly. The children could also share ideas and questions with their peers outside the context of the riddles in wider social interaction. Doing so they acquire linguistics and socio-linguistic competences fostered through interactions made among children (Trucker, 2009:12). Linguistic skills include phonological, grammatical phrases and clause structures and patterns used by children in different speech situations. When the children adjust what they say and the means of expressing it in the situations of turn taking interactions, they develop their sociolinguistic skills. Furthermore, children adopt, adapt and consistently maintain speech events which are appropriate to the condition of speech topics.

By and large, the pedagogical lesson of riddle is helpful in such cases as teaching how children talk, serving as source of their intellectual discipline, to train the children's minds, to develop their perceptual and descriptive skills, to test their wit and competence in culture specific values etc (Sutton-Smith and others, 1999:162-64). The primary goal of leisure activity riddling is to entertainment the children and pursued them which are considered as end (Sutton-Smith and others, 1999:163). Thus, leisure- time

riddling between children and adults is developed in the vicinity of the home at the moment when the practical obligations of the participants are limited.

The most significances of riddle for children are related to their language competence mastered during actual interactions. In this view a riddle is "type of solicitation or urgently asking routines characterized by speech acts that elicits a response" (Bauman in Smith and others, 1999:160). This implies the questions posed by initiating participants, first person asking questions on various issues and respondents giving answer in speech act or dialogue which enhance multidimensional skills. During this time communication as one of the determinant factors could be achieved through riddling process while forming oration skills, fluency and competent skill and manipulation process are the final out comes which resulted respected of one another in the community regardless of material well-being of the individuals. Hence, children's riddles play significant roles in maintaining the development of their cognitive, affective and psychomotor skills in the process of wider social interactions.

Normally, parents need to ensure their children's speaking ability and some forms of relationship they should maintain through riddles both at home and at school (Njoroge in Kenya, 1994:53). To do so, parents have to expose their children to the use of connected speech like in linguistic skills, children's dynamic knowledge and broad language skills, sub-skills and specific units. Njoroge in Kenya (1994:53-55) identified 5 of such themes which are summarized as follows.

Language competence skills-the mastery of children's first language is well promoted using riddles. This starts from the practicing of pronunciation and progresses to the level of children's practicing their mastery of variety of connected speech in language. These connected speeches are assumed to promote fluency and competence of the children include their speaking skills, sound system, listening skills, sentence structures, and new logical concepts related to the language, etc. Generally, language competence skills involve all primary skills consciously or unconsciously consider other skills.

Observational skills - from the earlier time, people had been relying widely on observational skills in their day to day activities like food gathering, traveling, planting, dancing, herding, hunting and defense in order to be keen observer of the nature and natural phenomena. Riddles also make the children to be curious observer of the (a) nature-insects, plants, animals, human life etc (b) phenomena- water, vegetation, night and day, seasons etc and (c) structure of objects- size, shape, density, color etc. In doing so, children observe and understand domestic and wild life their behavior and natural events from various perspectives.

Normative skills-children need to know and understand the norm or ethical values of their society's right from the early childhood. Children of different age group have to know their communities' acceptable and non-acceptable behaviors based on standard cultural norms. Here the adults' interference in the riddling processes is very important to socialize children, to enhance communal beliefs/practices, to train them on social taboo and civilization, etc.

Memory and intellectual skills- people with good memories and intellectual abilities are considered as the libraries of the community. Such person keeps all the great deeds and events of the community they recited from the attentive observation they have in different social gatherings. These peoples are also supposed to be the custodian of the community's folklore. The knowledge they acquire result from their predisposition to different folkloric genres right from their early childhood. Along this line, riddle is supposed to be powerful tools to catch children's attention and maintains their lasting memories. So parents' demonstration about their ancestral genealogy, past achievements, logical thinking and philosophical thoughts of their community to the children enhances their memory and intellectual skills.

Entertainment skills- in general children's folklore like storytelling, riddling, songs, dances and wrestling, etc. have been serving as the means of entertaining children. The entertainments are associated with some sorts of competition, exercise for body fitness, and other outstanding events exercised by community. When children get engaged in such folkloric genres for entertainment and relaxation, they amuse themselves during the riddling sessions. They also expected to develop the basic language skills. Presently, riddles are widely relied as the means of entertaining and hence need to linked with co-curricular activities, media broadcasts, provision of education and recreations.

Forms, Contents, Context and Procedures in Riddle

Riddles are characterized by different forms. These forms are riddle-jokes (for humorous events), riddle parodies (ridiculed establishing riddle), riddling question (to identify the referent) and joking questions (humorous punch, verbal and non-verbal riddles) (Tucker, 2009:23). Although riddle is similar to proverb in terms of forms and contents, the two genres vary in their occasional style. They are similar in forms for their conscious and brief presentation of messages, rhyme and tonal nature even the two forms are sometimes combined as proverb-riddle (Finnegan, 1973:426). On the other hand, the content of riddle often evokes of minor and childish interest as important subject of studies in oral literature; sometimes riddles have close connection with other forms of literary expression like enigmas, dilemma tales, stories (Finnegan: 1973:426). Thus, the writer discovered that the riddles in African society vary from simple form of phrases or statements to some well-known objects expressed in more or less valid languages.

The various African riddles including that of the Oromo's are also known in terms of their questioning and answering form and in terms of their brevity. Coming to the modality, most riddles are presented in interrogative routine incorporating some forms of solving ambiguous events (Tucker, 2009:24). This act involves dynamics of power in which the asker have full authority to tell the answer to the respondent or to judge the questions. However, to develop the critical thinking ability of the respondents, the asker gives ample time for the respondent so that s/he could examine various issues related to the riddle in questions till the final answer.

The context and interactional situation are very important in the studies of various folklore genres. In spite of its difficultly in answering riddle questions in depth, in folkloric and anthropological literature, children riddles are addressed replying to the when, where, how and with whom questions (Sutton-Smith and others, 1999:61). Most of the time riddles are considered to be acted out by children and during interactions; their intention is to achieve entertainment rather than series considerations. The riddle is proceeding by some sorts of open formula held between the asker or challenger and the respondents. If the respondents fail to respond the correct answer, the challenger asks him/her to provide him/her with imaginary markets serves as the source of progress and interaction of the riddle.

No matter how there are different situations based on the culture of the societies; people take part in riddling irrespective of age and time for riddling. Sutton-Smith and others (1999:62) pointed out that riddle starts with younger folks or children upon playing house, chatting around fire place, waiting a turn to pound rice, fetching water at resting time or after lunch. Nonetheless, the actual riddling is started by the young or children and the old folks get stimulated to participate depending on some objectives. The writers identified two categories of group of people in riddling in western tradition: (a) group's riddling opened to both adults and children, riddling being seen as an adult privilege and (b) riddle having active involvement of people based on age and social status of potential participants. In such a way in western tradition, riddles are created occasionally to children for testing their intelligence but they are not encouraged to participate.

In most African countries children are supposed to dominantly riddle to manipulate different skills. Hence parents enhance the children's use of riddle in both schools and at home to increases their exposure to speech acts and to ensure their speech competences (Njoroje in Bukenya, 1994:53) being promoted in riddle session (encompasses riddle acts and some sort of organization).Riddle session is a "series of riddle acts, possibly combined with other performance material and its organization to be

described in terms of three key pointes (Sutton-Smith and (1999:162). The three key points are (a) role relationships among the participants, (b) the conjoining of the interactional units that make up the sessions, and (c) restrictions or expectations influencing the selection of acts in one session relative to selection procedures in other sessions.

4. Data Presentations and Discussions

Overview

The keen observation on the general delivery of children's folklore, the exhaustive interview conducted with stake holders and close discussion made with key informants of the community show the existence of abundant children's folklore having different lessons in the study area. However, two contrasting views are identified on the current status and ways of transmitting children's folklore: (a) the existence of various opportunities to use children's folklore more than any other time and (b) the less attention given to folk traditions owing to various reasons.

With regard to the first view, the study shows the widespread and excess but yet unstudied children's folklore in the current time. The informants, key stake holders and cultural community have raised instances in line with many issues. As some informants pointed out, the folklore genres found both in the rural and urban areas of Hararghe become famous from time to time due to strong interaction among peoples of the two areas, their mobile nature, and peoples' love of their culture. Folklore is the means, by which people express their identities, maintain various social values, share their children division of labor, instill normative lesson in their children, and teach history and societal traditions. The informants also stated that subgenres of folklore like riddle, proverbs and narratives are the most potential areas. The view is also supported by modern folklore study which aimed at preserving folk life not merely for the sake of their orality but also assuming as the base of modern education with practical lessons.

Based on the second major view, the state of oral mode of communication in the area of children's folklore is seriously affected and their steady use by different social groups found to be decreasing. One interviewee attested saying "…the limited current use of folklore to express various encounters in every day communication may result in the final disappearance of folktales and riddles. Many people in the rural and urban areas have less concern to teach children using riddle and folktales'. A community's elders invited to narrate a story to children as he used to be told by his grandparents also gave feedback saying "…currently nobody uses folklore to teach children; in fact, it has no use, we teach our norms and values through Quran education called *madirasa.* Doing so, children can well understand their parents and obey to them. An elders stated that, "I don't help you in any narration as it is true for many peoples; I may rather help you in telling those values across religion ethics i.e. Islam". For the elder, the use of *Afaan Oromoo* to teach Quran education is much more important than the use of folktale to teach values. Such experiences might be resulted from community's strong commitments, adaptation and assimilation to Islamic religion value system which has weighed down Oromo indigenous value systems.

Another elder took part in focused group discussion explained the fact behind the deterioration of Oromo folklore traditions as

> *"Even if there are different verbal and non-verbal children's folklore in Oromo society in Hararhge area, many of them which I am familiar with during my childhood are not currently used by parents to advice, teach and impart moral lessons to children. Rather parents use verbal advice than children's folklore- a son by his father and a girl by her mother…"*

This man expressed about limited knowledge of people and poor transmission of children's folklore in the current time and emphasized the role of *Gadaa* and its ethics that prolongs the life span of Oromo traditions. He justified as " for all secular and religion lives of the Oromo society, *Gadaa* System is basic foundation" Accordingly, the advanced ethical and moral slandered (*safuu*) held in *Gadaa* is aliened to different age groups of children and this had been the concern of all Oromo clans regardless of their

religion. In the same vein, a folklore expert participated in focus group discussion, asserted "parents are negatively influenced by the past ideological attitudes that marginalized and discredited their tradition. As a result, they rarely tell their children about their traditions using folklore" This individual also indicated that especially most children of urban area prefer to narrate a story about European football player than about a personal story of a well known person in our culture.

In spite of the above major controversies, currently the children's folklore is prevalent in the study area. The society often uses them for various purposes in various settings: during the day time and at night. For instance parents use *sheekkoo* (fables) and *hiibboo* (riddle) to enhance cooperation and harmony among children, to teach them normative lessons, to develop their linguistic skills and to enhance their sense of identity. Irrespective of sex, age group, geographical location, family back ground, 6-18 years old children do actively use and recite the genres to express historical, socio-cultural, linguistic and other issues. Children themselves rely on the two genres to get out of dizzy mood, entertain themselves, maintain good communication with their peers, to pass society's traditions to the junior children, to justify children issues, etc.

In the subsequent section, riddles are annotated, transcribed, translated and presented for discussion in terms of their generic classification, structure, content, contextual functions and styles of performance enhanced during their delivery.

Riddle (*Hiiphoo* or *Hiibboo*)

A riddle, *hiiphoo* or *hiibboo* in *Afaan Oromoo*, is one of the prominent children's folklore in Oromo society. It is delivered in the form of questioning and answering; highly sophisticated genre in developing children's linguistic skills, increase their perception abilities, intellectual capabilities, critical thinking, creativity, and their oration and recitation skills; it teaches them precious social values. Different forms of riddles are also vital in maintaining good harmony among the family and the children, teach them socialization and make them fond as leisure time activities. Riddles are usually delivered by children to the children, adults acting as facilitators and audiences in a very limited context (at night). This time is more appropriate for riddling as children are free of works and cope up with detailed of riddling events in concentration until dinner is reserved. Riddle played out of context during the day is resulted in an insult *hiibboon guyyaa hinjiru, gobaan siyaadiru* (there is no riddle playing during the day, let a spear pierced you). This norm would limit the expansion of riddles to some extent.

Procedural performances of *Hiibboo*

Hiibboo is performed in some sort of sequenced procedures and opening and closing formula. The procedural chains of riddles are basically coherence and highly organized having its own peculiar performance nature. The steps involved can be classified as the on setting, the progressive and winding up stages. In the on setting stage, the children are invited to summon and sit either in linear or spherical positions around the fire place, on the tradition carpet or lying on the pillow while the invited parents and youth in the family are taking part in facilitating and listening to the riddlers , the listener acts the riddle out dialogically confining to specific rules outlined below.

> **Riddler**:*Hiibboo (Hiiphoo*)-let me deliver my riddle, (riddle) (for attention seeking)
>
> **Respondent:***Hibbakka / hiibib*-let me receive your riddle, (riddle) (for attention giving)
>
> **Riddler**:*Hiibbakkaa Rabbirraa taatee naafis siifis taatee,haajaan waltaatee, ajaa'iba Rabbii dachiin garaa qabdii, naaf beeki*-the riddle offered us from God, I and you get very comfortable with it, our objectives are fit to each other. Incredibility of the art of God, the earth gets pregnant. Just search and tell me the answer.
>
> **Respondent**:Tells the answer. It is sugar beet.
>
> **Riddler**:Agrees with the answer and appreciate the quick response the riddler gave.

It is obvious that for both secular and religious life Oromo society is restricted to the faith and willingness of *Waaqaa (Rabbbii*) in the above riddling. *Waaqaa* is believed as source of all things in the cosmic order. Therefore, everything is stated in reference to *Waaqaa (Rabbii)*. That is why, in the above riddling, it is said "*hiibbakkaa Rabbiraa taatee*… (the riddle offered us from God)…". The riddling becomes progressive if the respondent fails to provide the appropriate answer. At this juncture, the thinking of a respondent about things of the cosmic order becomes strong and gets expended. S/he engages in creative rationalization with regard to all being in the cosmic order or habitats assumed as reasonable answers. If still the respondent fails to arrive at the right answer, s/he asks the riddler the guiding questions to deduce the semantic field for the possible areas to discover the answers.

Riddler: *Hiibboo/ Hiphoo* / let me deliver my riddle, (riddle)!

Respondent: *Hiibbakka / hibib*: Let me receive your riddle, (riddle)!

Riddler: *Hibbakkaa rabbirraa taatee naafis siifis taatee, galgala oli, ganama gadi, iyyaafadhuu naaf himi*.

The riddle offered us from God, I and you get comfortable with it; it moves up during the night, it moves down in the morning. Just interrogate and tell me the answer.

Respondent: I don't know the answer; I should search and interrogate it. Can I?

Riddler: Yes, you can search and dig out the answer.

Respondent: Is it a wild beast or a domesticated animal?

Riddler: None of the two.

Respondent: Is it living being or non living being?

Riddler: It is non-living being.

Respondent: Is it aquatic or arboreal habitat?

Riddler: It is neither of the two habitats. *Dullumfattee* (couldn't you get the answer) ?

Respondent: *Ee dullumfadhe* (Yes, I couldn't get the answer)?

Riddler: *Haya biyya naaf kenni* (all right, give me the Country)

Respondent: *Haramayaa siif kenne* (I gave to you Haramaya)

Riddler: Haramaya is a beautiful town. Having this, I get everything, the answer is trouser.

After all the domain restriction that helps the riddler to get the correct answer, still the respondent may fail to find out it. Finally, a riddler is expected to ask a respondent to provide him or her with imaginary market or country. If one is not interest in the imaginary market/country, one can also refuse and seek for change of a better market/country. The market is assumed to be a place where every attractive thing is available so that the riddler can afford. After accepting a market, in Hrarghe setting, the expected respondent do not progressively articulate the feedback in rhythmic poem which is the thematic, artistic and with full of wisdom or thought at progressive sage. This gap of knowledge is created in the procedure of riddle due to the replacement of Oromo oral wisdom by Islamic religion value system and this indicates a paradigm shift. However, some individual of the area who had experiences of Tuulamaa and Maccaa Oromo traditions related that the riddler expresses his or her own view in rhythmic poem whose general content is wishing everything good for him or her and everything bad for no governing norms and which have governing norms (Table 1and Table 2 below). The rhythmic poems are said in a fast moving and melodic tune. Instances of such rhyming poem include the followings.

Table 1. Rhythmic response at progressive stage without governing norm.

Riddles in *Afaan Oromoo*	Translation
Riddler: Na hobaasi	Let you provide me with the drink
Respondent: Dhugi	Here it is, take the drink
Riddler Situ baksee, natu dhuga	You filter the butter, I drink it
Bishaan koo calala,	My water is clean
Dubbiin koo marara	My talk is attractive
Ofii goree buleen,	I escape the night to some one's house
Si goraarra bute	I push you along the thorny bush
Kan koo madaalatti	I feed in prominent tool
Kan kee qadaadatti	You feed in container's cover
Jimmaan sidhaqeen,	Taking you to Jimma
Jirmaan sidhahe.	I pushed you against trunk
Guutuu manaa siyaabsise,	I chased you till the apex of the hat
Duutuu namaa sitaasise	I proved you to be a nonsense person
Gufuu gugguuftuu jala bahi	Pass under the steady hindrance
Otoo dhuuftuu ganna bahi,	May you suffer in diarrhea during the summer
Muka baddaa baadhu	Carry the wood from the highland
Luka fardaa nyaadhu	May you consume the foot of the horse
Gufuu balbalaa ta'i ,	May you be stumbling block of the door
Harree sittaarigattu,	Let the donkey scratches her body against you
Xuwwee galgalaa ta'i	May you be the washing container used at night
Nadheen sittaadhiqattu,	Let the women served you to wash their cavity
Handaqiirra ciisi	Sleep on a hide
Albaatii gaddhiisi	Release the diarrhea there
Onborii naanna'i	Go round the yard
Hudduudhaan raamma'i	Let your button get rotten
Fardi hindannabsuu	The horse can't gallop
Kana caala sinarrabsuu	I don't insult you any more
Waraabessi adda booqaa	Let the hyena eats you
Qabee siyaafolloqsu	A white forehead hyena
Deebiin isaa kofoodha	The answer is trouser

One may feel that the above insulting deviate the culture and norm of the society. However, it is rather assumed as the means of educating children various lessons from different dimensions. These include teaching tolerance, making them active and creative thinker, serving as the tools for forming retaliation not to be beaten in their future life, to develop children's oration skills and critical thinking ability right from the beginning of childhood. At the same time the insult may also remark the ancillary status of the loser, who lost the riddle. Doing so, they would prepare themselves for active engagement in duties and responsibilities of the later age and adult lives. As indicated at events of progressive riddling stage, the riddler ends up the narration after receiving an imaginary market or country. Then, the negotiation is arrived between the riddler and the respondent who soon takes each other's position and continues the next round riddling. The respondents receive his or her start to challenge and have revenge by addressing unique questions and creating similar rhythmic poems. In some cases the rhythmic poems are said in a fast moving and melodic tune until finally the respondent said *saanqaa Waaqaa jala seene* (I hide myself behind the gate of God) as observed in table below. Here, the riddle is fully governed by *safuu* (norm) of Oromo belief in and fear of Supreme Being, Waaqaa.

Table 2. Rhythmic response at progressive stage with governing norm.

Riddles in *Afaan Oromoo*	Translation
Riddler:Haramayaa dhaaphee	After going to Haramaya market
Maalan dhaba.	Nothing is escaped from my sight
Shittoo shittoon kan kooti.	Items having good odor belong to me
Cittoo cittoon kan keeti,	Items having bad odor belong to you.
Gama koo mi'eessaa dhaabee.	I planted a tree with goododor in my side,
Gama kee haddheessaa dhaabee,	I planted a tree with badodor in your side.
Gama koo gundoo dhaabee,	I put a winnower in my side,
Gama koo gingilchaa dhaabee	I put a sifter in your side,
Malkaa Gaaraa ba'i ,	Got to the valley up the hill,
Qaamaan daaraa ta'i ,	May your body be covered with dust,
Tulluu didibbee ba''i.	Climb up the mountain which lack forest.
Nama Waaqni jibbe ta'e,	Be a person who is abandoned by the God.
Respondent: Saanqaa Waaqaa jala seene	I hide myself behind the gate of the God
Riddler Fardi hindanabsuu	The horse doesn't well gallop,
An sinarrabsu	I don't insult you anymore.
Hundee migiraa	As that of the root of the grass,
Hundeen nu fira	We came from one genealogical line.
Deebiin isaa kofoodha.	The answer of the riddle is a trouser.

In Table 2 above, the riddler is found insulting the respondent with full freedom as much as he/she can and finally the two individual come to terms. In this, the progress of poetic insulting through riddler-respondent interaction cannot remain active until the two persons coming to negotiation in riddler's answering the questions. The norm or *safuu* of Oromo religion is used as a governing principle in which case the riddler abstains from insulting the respondent in case s/he misses the correct answer. Such hard and fast rhythmic poem carried on by riddler with the main purpose to test his /her creative ability in poetic verses within a short second until the respondent says *saanqaa waaqaa jala seenee*. Hearing such statement, the riddler automatically stops insulting the respondent any more .This makes the riddle to be concluded I a harmonious way wherein the participants value each other for fear of *Waaqaa*.

Classification and Analysis of Riddle (*Hiibboo*)

The classifications and analysis of riddles can be presented in two different ways. These are the classifications based on structure and content or function. Classification of the riddle in this manner is essential to teach the children various languages and linguistic elements and examine the values and wisdom communicated through riddles. The structural classification dominantly helps the children to learn linguistic skills (like phrase, clause, sentences, parts of speech), sociolinguistic skills (turn taking interaction, speech acts, maxim of speech quantity, quality, relevance and trustfulness); language skills (speaking, listening, oration) etc.

On the other hand, content or functional classification enables the children to distinguish thematic categories of things, semantic fields/ domains, lexical items, subjects of creativities, philosophical and logical thinking and the familiarization of children with social values (harmony, honesty, respect, free and democratic interaction). They also learn different historical, educational, entertaining lessons, socio-cultural practices, society's worldview or its cosmological phenomena. The content and functions of riddle are also the base for children to analyze the nature, scope, wisdom and significant of oral

communication events. In the subsequent titles attempts will be made to elaborate certain classifications and analysis of riddles.

Structural classifications and analysis

Structural classification is examined based on the types of riddling questions. The two known structural classification of riddles are (a) simple and compound riddles and (b) complex riddles. The first riddles are related by simple or compound sentences and their answers are words or phrases. Based on riddling questions, this category can be, either positively or negatively compared, double denial, numerically expressed riddles; riddles focused on very mysterious events and riddles associated with places and materials. These kinds of riddles are easy to manipulate and understand by children. Children use them widely and they are the most productive ones. The complex riddles are composed of two or more sentences or riddling questions. Alternatively, they have also more than two answers. Unlike the simple riddles and its forms, the complex riddles are very limited and are not commonly produced by children because of their complex nature. However, some times the matured children and adults are involved in riddling them or they guide the children in the riddling process. The above two categories and their sub classifications are presented in the subsequent tables.

In positive comparison, one object is expressed in terms of two similar attribute or two objects are described in terms of similar features through comparison.

Table 3. Riddles presented in positive comparison form.

Riddle	Response
Jalaan ni xuqa gubbaan ni xinniqa	*Maashoo*
In the bottom it pushes up; in the top it overflows	Lantern
Adda nyaateet bookkisa, nama rafe dammaqsa	*Dibbee*
It eats in unique way, it awakens one who got asleep	Drum
Aabbaa fakkaata baala nyaata	*Re'ee*
It seems the monk, it eats a leave	Goat
Yemmuun deemu nacina deema, yemmuun ciisu nawaliin ciisa	*Gaaddidduu*
When I walk, it walks near me, when I get sleep, it sleeps with me	Shadow
Akka ayyaana keenyaa, allayyaarra teenya	*Harma namaa*
Like our ayyaanaa, we sit on the top of the valley	Women's Breast

Some riddles are presented in the form of negative comparison. In this case one object is characterized in terms of two similar attributes or features. Alternatively, two objects are characterized in terms of similar features/ attributes through comparison.

Table 4. Riddles presented in negative comparison form.

Riddle	Response
Ani qal'aadha, namni jagnoomee na hinxuqu	*Shiboo elektirikaa*
I am thin, famous person is not dare enough to attack me	Electric wire
Galgala oli , ganama gadi	*Kofoo*
Taller than people at night, shorter than people during day time	Trousers
Laaltu dhagaa nyaattu dhadhaa	*Mixaaxisha*
When you look, it is a stone; when you eat, it is butter	Sugar beet
Halkanii *guyyaa deema, hindadhabu*	*Bishaan*
It walks day and night, it doesn't get tired	Water

Halkan namaa ol guyyaa namaa gadi	*Lukkuu*
Senior to people in the night junior to them in the day	Cock
Halkan sooresa guyaa deegaa	*Dallaa loonii*
Rich during the night, poor during the day	Animal fence
Ija wajjin dhalatee otoo hinlaaliin du'e	*Biddeena*
It born with eyes, it died without seeing.	Budena

There is the dual denial form of riddle. This category of riddle includes the riddles which are identified by two or more negation. They are marked either by negative prefix (hin-un-) or the entire idea stands for negative senses.

Table 5. Riddles presented in dual denial form.

Riddle	Response
Shok hinjedhu sokok hinjedhu ce'ee bahe	*Yaada*
It doesn't move; it doesn't make noise, it rushes out.	Idea
Bishaan osoo hinroobiin burqe, otoo hingoggogiin dhume	*Immimmaan*
Water comes without rain, which lost without getting dry	Tear
Hilkaan hinqabuu dheedhii nyaachuu hindadhabu	*Lukkuu*
It doesn't have a teeth, it doesn't fail to eat grains	Hen
Haadhas hinfakkaatu abbaas hinfakkaatu	*Gaangoo*
It nether seems its mother nor its father	Mule
Luka malee gara fedhe dhaqa ilkaan malee nama nyaata	*Yaada*
Without feet he goes everywhere, without teeth it eats one	Idea
Mana hinqabdu nyaata hindhabdu	*Tafkii*
It hasn't home to live; it hasn't what to eat	Flea
Fayyaan du'aadha dhale, du'aan fayyaadha dhale	*Killee*
The normal gave birth to the death; the death to the normal	Egg
Qaban qabaa hinguuttu gad dhiisan dachii hinfuutu	*Ija*
When held it is small, when released to the ground, it does/t occupy it	Eye

The other form of riddle is riddle which is associated with places and materials used by people. Hence, upon riddling the riddler refers to houses, hills or mountain, plots of land, materials used by people. The responder tries to analyze the things directly or indirectly making an association with place names and objects.

Table 6. Riddles associated with places and materials.

Riddler	Response
Manneen kiyya gaara gubbaa jiru	*Uuruu*
My houses are up the hill	Nostril
Maasii bal'aa keessa shumburaa facaase	*Urjii*
I saw a chickpea in a huge field	Stars
Jibichi kiyya gurraachi siree keessa gangalata	*Injiree*
Our black calf rolling in the bed	Lice
Abbaa guddaan gaararra taa'ee dabtara bana	*Billaacha*

The gentleman up the hill opens the exercise book	Butterfly
As taa'ee gamasitti waraane	*Ija*
Being here it strikes something in the other side	Eye
Asii biifeen baargamati tiife	*Fixeeynsa*
I spray from this side to the distant place	Dew point
Namni tokko tulluu gamaarraa hoomaa saree gad oofa	*Millaaccii*
A persan rides down a hard of dog along the hill	Razor / blade

The riddles associated with mysterious objects are the other category of structural form. Although the major focused of riddles in this category are issues of very mysterious events that the children entertain with and develop various imaginations with main purpose to solve mysterious events, they are not mutually mutual exclusive in terms of their structure.

Table 7. Riddles associated with very mysterious objects.

Riddle	Response
Afaaniin nyaata afaaniin udaana	*Baaburii*
It consumes and removes the waste in its mouth	Millstone
Garaa haadhaa keessa baatee kan haadha rukuttu	*Kibriita*
Who beat her mother emerging from her mother's stomach	Match
Anoo asin sikaa'ee maaltu achiin sibaase?	*Dabaaqula*
I put you nearer, who takes you afar?	Pumpkin plant
Fayyaan *duutuu ilaaltee, duutuun fayyaa ilaalte*	*Lukkuufi killee*
The living looks at the dead, the dead looks at the living	Hen and egg
Afaan isaa waraabessaaf, udduun isaa namaafi	*Balbala manaa*
Its buttock protects a hyena, its mouth protect a human being	The door
Fagaaraan nyaata; afaaniin haga	*Qawwee*
It consumes in its anus, it removes the waste through mouth	Gun
Jiraa du'aa baadhaatu, du'aa jiraa baadhatu	*Farda, kooraa, nama*
The dead carries the living; the living carries the dead	Horse, saddle, a man

The other category of riddles is numerically expressed riddle. This includes riddles which are related quantitatively measured events, incidents, practices, etc and counted by number. Such kinds of riddles are also found under complex riddle.

Table 8. Numerically expressed riddles.

Riddle	Response
Muka guddaa damee 12 qabu, dameen 1 baala 30 qaba	*Waggaa, ji'aafi baatii*
A tree has 12 brunches, 1 of its brunches has 30 leaves	Year, month and day
Aabba ijoollee 5 qaba; 5 nu wal bira jiraartu	*Qubeen*
The old man has 5 children, 5 of them live side by side	Fingers
The two released dirrhea, the other two made the diarrhée	Mucus and finages
Hiriyaa laman walfakkaattu waliin deemti	*Kophee*

The two similar friends walk together	Shoes
Tokko ni teenya jedha tokko ni deemna jedha	*Bobbaafi fincaanii*
One wants to go and the other one wants to sit down	Urine andwaste
Waa sadii waa sadii baata	*Gaazuuweefi eeloo*
The three things hold three things	Oven holder and oven

There are two forms of complex riddles. These are riddles which are composed of two or more questions and answers, riddles which have one question and two or more answers and riddles addressed by two or more questions but which have one answer. Such kinds of riddles are rarely available and very often used by children of the study areas. Sometimes the adults and the youth can narrate them from their memory. Both are presented in the tables 9 (a) 9 (b) below.

Table 9 (a). Complex riddles involving two or more questions and two or more answers.

Riddle	Response
1. ***Barcuma dheeraa hondoloqaa*/he long wide stool**	Eegee horii /Cattle's tail)
***Warra Qaalluu sabakataa*/the disordered *Qalluu* family)** .	Garaacha, / Intestine
***Namicha laagaa adii* /the man with a white throat**	Moora horii/Cattle'slatex
2. ***Waa sadii kan waliin dorgoma*n**	Zaa,Daqiiqaafi Sakondii
The three things which compared one to the other	Hour, minute and second
***Muka guddaa damee* 12 / A big tree with 12 brunches,**	Waggaa, Baatii, Guyyaa
Dameen 1 baala 30 qaba/ 1 brunches has 30 leaves	Year, Month, Gay
3. ***Eeleen koo bal'oo* / My oven is wide**	Samii / Sky
***Ijolleen koo baay'ee* /My children are plenty**	Urrii / Star
***Bukoon koo qal'ate*/ My dough is soft**	Rooba / rain
4. ***Jiraa du'aa baatu*/ The dead carries the living one**	Farda, kooraa fi nama
***Du'aa jiraa baatu* / The living one carries the dead**	A horse, a saddle,a man
5. ***Yemmuu bitan gurraacha* / When bought, it is black**	Kasala / Charcoal
***Yemmuu fayyadaman diimaa* / When used, it is red**	Ibidda / Fire
***Yemmuu gatan adii* / When thrown away, it is white.**	Daaraa / Ash
6. ***Abbaan koo dheeraadha* / My father is tall**	Muka, gaaguraa, kanniisa
***Haati koo gabaabduudha*/ My mother is short**	Tree, hive and bees
***Keessummaan koo hedduudha* / My guests are many.**	

Table 9 (b). Complex riddles with 1 question-2 or more answers and vice versa.

Riddle and Answer Riddle and Answer

`*Asiin gaara* / this side is a hill.	***Asiin gaara* /this side is a hill**
***Achiin gaara* /that side is also a hill**	*Achiin gaara* /that side is also a hill
***Jidduun boombiin dhohe/* In-between the gun get exploded**	*Jidduun farasmagaalaa* /In-between there is a bus station
Anawers: *Dhuufuu* / Fart	Answer: *Shuroo Aannanii* / Porridge
Riddle : *Waa jaha diniq*!	The six incredible things!
Answe: *Hiddii rooba malee gabbatu*	The water flows on the bank without any push
Bishan hoofan malee deemu	The land gets stretched without people's act
Waaqa utubaa malee dhaabbatu	The sky tends to erect without a pillar
Qoree qaran malee qaramtu	The sharpened thorn without one sharpening it
Huummoo dhukkuba malee aadu	The outstretch gets moaning without illness
Bofa miilla malee lo'u	The snake dragged without foot

Content and functional classifications

Classification of riddles based on their contents and functions are related to the analysis of riddling questions and answers. The vast areas of contents of riddles holds together things of the cosmic order in which children get inputs by expanding their imaginations, getting motivation towards creativity and critical thinking, acquiring intellectual and cognitive knowledge, insisting on general and specific skills etc. The potential contents areas where riddles touch up on include objects/tools, living and non-living beings, concrete and abstract things, kinship and genealogical patterns, natural phenomena and imaginative thinking etc.

Both the contents and functions of riddles are complementary and its questions and answers cannot be understood exclusive of functions of riddles. Hence, the common functions of riddles are related to entertaining and educating. These functions of the riddle appear to be the most useful and in multiple ways. For example, from riddling questions and answers, children develop mechanism of challenging, art and style of speech, logical reasoning against or for premises, creativity in counter attack in speech, debating etc which are mainly means of educating and entertaining children in such context where modern way of educating and means of entertaining them could be limited. The cognitive, affective and psychomotor skills of children can also be reinforced through process of riddling while educating and entertaining children. Thus, children develop various language skills and sub skills that make them sharpen or matured enough in social interaction and socialization process. They develop language competence, observation, norm, memory and intellectual skills. Though there are various content areas of riddles, the major ones that have great impact in daily lives of the children and used by adults in one or another ways are outlined below.

Semantic domain (Fields)

For any language learner, the identification of semantic domain is the primary focus to know a language and its structures. In this regard, analyzing the answer for riddles, there are various semantic domains or fields with various attributes, features and qualities useful for the children and by the parents who teach their children various educational and linguistic domains in informal setting. The basic semantic fields with their prototype observed by analyzing answers of the riddles include: plant and animal species, animals with different habitats, types of crops, furniture and kitchen tools, parts of the body, food varieties, natural phenomena, kinship terminology etc. These aspects of the contents of the riddle are helpful especially for the children to develop their collocating skills, their concept formation, lexical production and sense relation among words. The children also learn parts of speech, forms of sentences, their functions, and various forms of sentence structures especially by examining riddling questions.

Philosophical lessons

After having input from semantic domains, children must conceptualize things in the real world and develop their own ways of philosophical thinking and concept formation. Thus, the riddling questions enable the children to broaden their philosophical and logical thinking. In the process of searching answers is which related to the diddling questions and in the process of insulting one another, the participants of the riddle discover and imagine different phenomenon or things from various dimensions. They think of the shapes and size of objects, their colors and physical appearances; they identify their functions, they identify the merits and demerits of things, their habitats, behaviors, advantages and disadvantage of objects. They rationalize things to be addressed by leading questions and try to deduce various related phenomena, objects, things, step by stem and arrive at the correct answers through logical reasoning and concept formation. They examine things explicitly or implicitly stated, things related symbolically, metaphorically, analogically, thematically, etc in terms of their logical and categorical relationships. In dealing with diverse matters in the entire situation of riddle session and procedures, the participants develop their philosophical thinking in various angles.

Values and cultural norms

The society is shaped by their specific norms imbibed in a wide culture that shape the society. Likewise, riddles are one way of expressing peoples cultural and the underlined social norms. They provide the children with invaluable values and normative lessons in which one can achieve in daily interaction through riddling. When communicating through riddles, children discover ethical and unethical issues, taboos, cultural expressions, cultural food and clothes, etc. They impart the past history and tradition of their society. Specially, the playing of riddles gives opportunity for children to count their *sanyii haadhaafi abbaa* (paternal and maternal lineages) and *hiddadhalootaa / latiinsa* (genealogical patterns).

The children get chance to teach each other of their social hierarchical structure like *maatii* (family), *ibidda* (lineage), *balbala* (clan), *lammii*(major clan), *gosa* (tribe), *sanyii* (ethnic), *biyyaa* (country) and finally *Oromummaa* (Oromo hood).Throughout the relation and at high level, the socialization, and sense of self esteem and consciousness of one's ethnic identities are upheld. Consequently, children love their language, their culture, and develop sense of belongingness and identity formation. In general, the functions of riddles to restore values and social norms enable the children to get rid of socially unethical issues and get familiarized with acceptable social norms. These contribute a lot towards making the children rational and ethical society, the determent factors in their later ages and for the development of citizen as a whole.

5. Conclusion

The studies of knowledge and wisdom imparted through oral traditions achieve multi dimensional purposes. In addition to serving as the source of desirable educational outcomes, it teaches the various functions of traditions and customs of the society. However, many of the societies' folkloric tradition have not been properly studied. The existing works are fragmented and lack appropriate scientific documentation both textually and digitally. This result in the limited uses, inadequate benefit less expected standard of oral knowledge and wisdom among the society. In spite of this, folklore as indigenous knowledge and wisdom have been utilized as realizable and relevant sources of knowledge which properly guide people towards understanding the living conditions of the society, their values, their world outlooks, their ritual and secular lives, and their humanity as a whole. Children's folklore is one of the most important forms of folk genres through which multidimensional lessons are inculcated into children. They enable children to exploit their experience to give sense to the world. They rely on such folklore to attack bad behavior and reinforce good behavior.

The Oromo in Hararghe (*Ituu* and *AfranQalloo*) is unique in terms of exchanging views and at the same time in expressing their ideas using folkloric genres disregarding rural and urban sites. This consistency is

largely related to *jimaa* ceremony which attracts as many people as possible across age, sex, economic, social and political background. This communal ceremony exists among different social segments and creates good opportunities for the materialization of orally transmitted folkloric traditions as sources of knowledge and means of teaching members of the society. Besides serving as the source of modern education and means of transmitting realistic lessons in the day today life of the people, many of such folkloric genres are the source of artistic principles and means expressing people's living conditions spatially and temporally. Riddles are such genres which are widely available in theory but scarcely found in practice in the study area.

The existing forms of the genre help the community to teach the children in multiple ways. They are sources of children's cognitive, social and psychological developments. They used as means of educating children about the arts, wisdom, norms, socialization process, critical thinking, creativities, oration skills, linguistic skills. They also teach the children basic language skills, memory and intellectual skills, entertainment skills, normative skills, observational skills and language competence skills. Parents rely on specific children's folkloric genres like riddle to criticize children, to express their love, to appreciate them, to attack their misbehaving, to shape and train them about social norms, to teach their history and culture, to train them in secular and religion practices, and to control children's violation of norms. By inculcating such lessons and virtues into children, eventually the society produce children who are active, productive, have sense of belonging and finally become good citizens. Therefore, the studies of folklore in general and children's folklore in particular could be conducted either separately or independently at various level of the society to empower the cultural groups, their language and their traditions by promoting their findings through modern education systems.

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2. Critical Analysis of Adult Education in some Selected Training Centers of Eastern Regions

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Abstract: The purpose of this study was to analyze the factors affecting adult education in the eastern part of Ethiopia. The study employed a survey design that involved qualitative and quantitative approaches. A stratified random sampling technique was used to select 515 male and 285 female respondents. A questionnaire and an interview for collecting information from the primary sources were designed and implemented. Data were analyzed with linear correlation and Ordinary Least Square (OLS) regression. The findings indicated that the relationship of overall adult learning achievement to assessment of learning ($r = 0,29$, $P < 0,01$), and the methods used by facilitators ($r = 0,23$, $P < 0,01$) is positive and significant. The regression model demonstrated that overall adult learning condition is significantly affected by variables such as relevance of the content, methods of teaching, assessment of learning outcome, and locality of the adult education learners.

Keywords: adult education program; training centers; curriculum relevance

1. Introduction

Education played big role as a major driver of economic competitiveness in an increasingly knowledge-driven global economy. Contemporary society has high expectations of the contribution that education can make in helping people learn to live with change, to lead change, and to support improvement in all spheres of life (Kala & Chaubey, 2015). Education is a prerequisite for short and long-term economic growth. As a result, no country has achieved continuous and rapid economic growth without at least 40 percent of adults being able to read and write (Merriam & Cunningham, 2007). The formal system, which is elitist, discriminatory and installment, cannot alone help man to attain all education he needs for achievement of self-fulfillment and national development. Terminologies, such as, adult education, continuing education, recurrent education, education permanent, and lifelong education, have been used by different bodies to stress that education is a very useful tool to our life (Torres, 2006).

Kanukisya (2008) noted that the term 'adult education' is used with at least three different meanings. In its broadest sense, it describes the entire process of adults learning. In its more technical meaning, 'adult education' describes a set of organized activities to a wide variety of institutions for the accomplishment of specific educational objectives. The third meaning combines all of these processes and activities into the idea of a movement or field of social practice. In this sense, 'adult education' brings together into a discrete social system all the individuals, institutions, and associations concerned with the education of adults and perceives them as working toward common goals of improving the methods and materials of adult learning, extending the opportunities for adults to learn, and advancing the general level of life (Nafukho, *et al.,* 2011).

The document compiled by UNESCO (2010) argues that literate, numerate, and problem- solving

workers who can add value to the production of goods and services at every possible point are needed. In order to improve learner participation in developmental programs, learning opportunities must be created by making education accessible to all. The introduction of adult and lifelong learning in the workplace is the first step to personal, educational and skills development. Tight (1996) contended that promotion at work often depends on an individual's ability to read and write local and international language in order to read job cards, write reports, follow written directions and instructions. Sabo *et al.,* (2006) concurred with the former by recognizing that adult learning would be a key issue in the twenty-first century and stress its importance for sustainable development, promoting democracy, justice, gender equity and other aspects of development, and ultimately for building a better and more peaceful society.

Among the characteristic features of adults, mental maturity and social responsibility are included. It is through adult education that adults are helped to mentally articulate to understand issues and judge rightly, and are able to perceive reality in order to creditably discharge their social roles as parents and leaders. For instance, mothers have to know the new responsibilities placed on them over the family from time to time. Also, fathers should be made to understand their roles at any point in time as the changing socio-economic realities of their countries. Nowadays, there have been programs organized for nursing mothers to intimate them with the need for breast-feeding, family planning and new approach to child-rearing (Tilak, 2006). The series of outreach programs organized by different institutions through different strategies is to bring to the knowledge of adults, men and women, the problems and solutions to different diseases, such as cholera, tapeworm and hepatitis (UNESCO, 2007). Thus, one could assert that the whole society has constituted training through which adults continuously learn and attain fullness in all its ramifications. That is, in every section of the society, different and necessary education programs are continuously offered to adults. This results in improved quality of life of which modern society is blessed with (Nafukho, *et al*., 2011).

In Ethiopia, as a result of the implementation of successive education sector development programs, access to formal schooling has significantly grown from its previous low level. However, in 2008, the Ministry of Education clearly disclosed the fact that the status of adult education in Ethiopia remained low in terms of both accessibility and relevance. Adult education programs implemented so far had not been geared towards problem-solving and was not relevant to the day-to-day life of the adult population (Ministry of Education, 2008a). Adult education plays both complementary and supplementary roles in education in a country. Consequently, Ethiopia should heighten efforts in adult education so as to afford citizens opportunities to attain self-fulfillment and national development in the twenty-first century.

In order to alleviate the adult education problems, as how Education Sector Development Program III (Ministry of Education, 2005) put it that life skill-based, work-oriented and community- based adult education programs must be scaled up. The attention to adult education is to convey essential knowledge and skills among adults and to facilitate conditions for the provision of Functional Adult Literacy (FAL) programs. In addition, it is designed to create milieu to adults to read and write in order to acquire knowledge and skills in agriculture, health, civic education, cultural education, etc. To this end, the strategy for adult education was developed with the active participation of all stakeholders in 2008. Nevertheless, the current adult education program has faced enormous problems accumulated through years. The strategic document uncovered the reality that the number of adult illiterates has remained high, and the issue has become the major challenge and priority area in the sector (Ministry of Education, 2005; Ministry of Education, 2008b).

ESDP IV also foresees a major program in Ethiopian adult education program (the objective of which is to allow all adult illiterates to participate in two years of Functional Adult Literacy (FAL) courses. The emphasis has been shifted towards FAL to ensure active participation of the literate population in the socio-economic development of the nation. A Master Plan for Adult Education has been drafted. It is expected to devote efforts in this sub-sector during ESDP IV implementation

(MoE, 2010).

The purpose of this research was, therefore, to analyze those factors that debilitate or facilitate the existing adult education program. In a more explicit manner, an attempt was made to identify the variables that most likely determine the success of adult education program in the Eastern part of Ethiopia. Moreover, effort was also made to examine the relationships between or among variables that determine the learners' success in the existing adult education deliberation.

This research is rooted from several research questions namely: (1) Which variables are significantly associated to the success of learners in the existing adult education programs? (2) What aspects of the program do adult learners experience as a challenge? (3) Which barriers are accountable to affect learners' achievement in the current adult education program?

2. Methods

The main objective of this research was to solicit the factors that best contribute towards the attainment of adult learning program in the Western and Eastern Hararghe, Dire Dawa, Harar, and Jigjiga. In order to attain this general objective, the study employed a survey design that involves qualitative and quantitative research approaches (mixed research design). According to Best and Khan (2005), survey involves acquiring information about one or more group of people, asking them questions and tabulating their answers. The ultimate goal of a survey research design is to learn about a large population by surveying their representative sample, summarizing their responses in percentages, frequency, as well as with more sophisticated statistical methods (Sarantakos, 2005). Survey helps to identify the major practice, opinions, suggestions and comments pertaining to the issue under study.

In order to address the fulfillments of a survey design, both primary and secondary sources of data were used to collect the required information. The primary data were collected from adult learners and adult education coordinators. Moreover, the study encompasses secondary data sources like National Adult Education Strategy (Ministry of Education, 2008b), Integrated Functional Adult Literacy Curriculum Framework (Ministry of Education, 2011a), Functional Adult Literacy Implementation Guideline (Ministry of Education, 2011b), and National Report on the Development and State of the Art of Adult Education Program (Ministry of Education, 2008a). Likewise, reports, research articles, education statistics and important plans produced by Regional Education Bureau and Woreda Education Offices and other adult education agents were also scrutinized.

The populations of this research were adult learners found in Harar, Dire Dawa, Eastern and Western Hararghe Zones and Jigjiga Town (all are in the Eastern part of Ethiopia). Overall, about 800 research participants were included. A stratified random sampling technique was used to select the sample learners of which 515 of them were male and 285 female respondents. For the purpose of interview, about20 respondents were also considered.A questionnaire was employed as a major tool to collect information from the primary sources of the data. The questionnaire has two parts in which the first part of it aimed at obtaining biographical information about respondents. The second part designed to secure information about the actual practices of adult learning programs. In order to assure the truthfulness and internal consistency of the tool, a pilot test was conducted. Accordingly, the following result was obtained, as seen in Table 1.

Table 1. Reliability Statistics.

Category of items	Number of items	Cronbach's Alpha
Items related to relevance of adult education program	10	0,88
Items related to teaching – learning process	10	0,92
Items related to assessment of learning outcome	11	0,98
Overall	31	0,906

The Crombach Alpha reliability coefficient of tryout test result indicates that the questionnaire has a reliability coefficient of 0,88, 0,92 and 0,98 with overall coefficient of 0,91. Based upon Gay and Air asian criteria for accepting a research tool, the reliability coefficient should attain greater or equal to 0,7 (Gay & Airasian, 2003). Hence, the above list of coefficients of reliability was accepted. Moreover, through face validity the items used in the questionnaire were also checked. This helped to improve the quality and credibility of the instruments. Based on the comments given, the sequence and problems of items were rectified and restructured to make the questionnaires clear and ready for the final use. Moreover, to prevent test contamination, participants who had taken part in the pilot test were purposely excluded from the study. The questionnaire was distributed for about 800 respondents (through educational supervisors and teachers' development process owners and experts).

In addition to the questionnaire, interview was also considered as a mean for securing important data. To get detail information, 10 items of semi-structured interview were designed to 8*Woreda* Education Office experts and 12 facilitators. The main purpose of the interviews was to obtain detail information about the practices of adult education program. This procedure helped the researchers to triangulate and strengthen the information obtained through the questionnaire. In this regard, facilitators, coordinators and experts were asked to offer additional verbal information on the top of the review of documents about the current practices of adult education.

After collecting the necessary information, the data was edited and reduced at first and then tallied, tabulated and processed separately for each item in a way to seek appropriate answer to the basic research questions. Both quantitative and qualitative data analysis methods were used. The data collected through close-ended questionnaire were analyzed quantitatively while the data secured through interview and document analysis were reiterated qualitatively. For the quantitative data, the analysis was made using SPSS software (version 20). More importantly, correlation and regression analysis were used to deliberate quantitative methods of data analysis. On the other hand, the qualitative data analysis was analyzed through thematic description and word narration.

Also, as a part of this investigation, essential ethical principles were followed to ensure that the participants of the study were treated with respect and consideration. Before proceeding with data collection and analysis, approval was sought from the Office of the Vice-President for Research Affairs. Moreover, permission was obtained from the administrative personnel *Woreda* Education Offices. The participants were informed of the nature and procedures of the study. They were informed that their participation was voluntary and they had the right to withdraw from the study at any time. Every effort was made to ensure the confidentiality and anonymity of the participants, including removal of names and details from quotes and descriptions that might reveal the identity of an individual. After the completion of the interviews, participants were given opportunity to review their responses and to make any changes to their statements.

3. Results and Discussions

Inter-correlation among the various dimensions of adult learning (Content Relevance, Methods of Teaching, Overall outcome of AE, Assessment of Learning, Sex, Age, Marital Status, and Locality) were examined in order to discern the relationship between independent variables (Content Relevance, Methods of Teaching, Overall outcome of AE, Assessment of Learning, Sex, Age, Marital status, and Locality) with dependent variable (overall adult education learning). Determination of relationship between dependent variable and independent variables was found important in order to deal with further regression analysis. Table 2 presents the outcome of correlation among the respondents' variables.

Table 2. Correlation Matrix of Adult Education Variables.

	1	2	3	4	5	6	7	8
Content Relevance	1							
Methods of Teaching	-0,037	1						
Overall outcome of AE	0,118**	0,212**	1					
Assessment of learning	-0,510**	-0,287**	0,193**	1				
Sex	0,112**	-0,070	-0,014	-0,117**	1			
Age	0,183**	-0,357**	-0,049	-0,024	0,017	1		
Marital status	0,400**	-0,107*	0,069	-0,163**	0,094*	0,278**	1	
Locality	0,043	-0,113*	0,119**	0,055	0,000	0,074	0,115**	1

***. Correlation is significant at the 0.01 level *. Correlation is significant at the 0.05 level.*

As indicated in Table 2, the interrelationships of most variables considered were significant. Specifically, the relationship of overall outcome to content relevance (r = 0,12, P < 0,01), to methods of teaching (r = 0,21, P < 0,01), assessment of learning (r = 0,19, P < 0,01), locality (r = 0,12, P <0,01) were positive and significant. Overall, the independent variables (content relevance, locality of the adult learners, methods and assessment of learning process) were significantly correlated to the dependent variable (overall outcome of adult learning) at 0,01 and 0,05 levels of significance. Hence, it was found important to extend the regression analysis to examine the effect of independent variables on the dependent variable.

Ordinary Least Square (OLS) regression was employed to provide information about the model as a whole, and the relative contribution of each of the variables that make up the model. OLS is much more appropriate when the dependent variable is measured in an interval and continuous scale. To this effect, in order to identify the variable(s) that affect to the overall achievement of adult learning, the regression model with variables, content relevance, methods of teaching, assessment of learning, sex, age, marital status, and locality were examined (See below in Table 3 & 4).

Table 3. The Regression Model.

	Model	Model	Df	Mean	F	Sig
1	Regression	379,747	7	54,250	3,429	0,002
	Residual	4508,925	285	15,821		
	Total	4888,672	292			

In Table 3, the significant F-value of the ANOVA analysis reiterate that the model (Y = 15,3 + 0,21x + 0,19x + 0,15x + 0,13x - 0,05x + 0,04x – 0,01x) fits the data very well. It means the overall explanatory state of the model was powerful. Hence, the result obtained on the basis of this regression model could steadily be regarded as dependable.

Table 4. The Regression Coefficient

Unstandardized

Standardized

Model	Coefficients	Coefficients		T		Sig.
B	Std. Error	Beta				
1	(Constant)	15,271	3,352		4,555	0,000
	Content Relevance	0,176	0,350	0,036	0,501	0,617
	Methods of	2,557	0,423	0,210	1,315	0,001
	Assessment learning	3,149	1,121	0,199	2,810	0,005
	Sex	-0,125	0,516	-0,014	-0,242	0,809
	Age	-0,022	0,027	-0,057	-0,844	0,399
	Marital status	1,673	0,801	0,131	2,088	0,038
	Locality	1,697	0,656	0,153	2,588	0,010

a. Dependent Variable: Overall Outcome of AEL

Following the formation of the regression model, the result designates that the overall adult learning condition was affected significantly by variables, methods and assessment of learning, marital status and locality of learning situation. It is fact, when the adult education curriculum is relevant to the life of adults, their interest and overall achievement in retaining and translation knowledge to their life is sustainable. In this regard, Courtney (1989) coined that the learning process must take into account on how an adult perceives and what is being taught. It includes, but is not limited to considering their previous learning experiences and their temporal perspective - especially when it comes to short term application of what is being taught, and matching education to their problems, needs, interests and expectations.

The findings of this study assured that the overall outcome of the adult education program is highly affected by the way and the method of assessment employed by adult education facilitators. According to Jones (2005), successful assessment for learning strategies result in improved learner progress on a continual basis. The principal characteristic of assessment for learning is effective feedback provided by moderators to learners on their progress. The value of the feedback is dependent on two factors, the quality of the feedback, and how learners receive and ultimately use it. These are important points for effective learning.

Research in the area of adult education emphasized that the learning result of adult learners can also be determined by the methodological approaches employed by facilitators and the way the learning achievement assessed by those who in one way or another involved in adult teaching learning process. Galbraith (2004) emphasized that being part of an effective educator involves understanding how adults learn best. Andragogy is a theory that holds a set of assumptions about how adults learn. Andragogy emphasizes to value the process and methods of learning. It uses approaches to learning that are problem-based and collaborative rather than didactic, the emphasis more on equality between the teacher and learner.

Collaborative learning as an element of andragogy has effects on the outcome of adult learning. A number of meta-analyses support the premise that collaboration "works" for promoting a broad range of student learning outcomes. In particular, collaboration enhances academic achievement, learners' attitudes, and retention (Prince, 2004).

One expert in adult education sector of the Harari region, Ethiopia suggested that the perception of facilitators in the enactment of adult education program affect the learning outcome positively or negatively. In the current situation, it is difficult to conclude that facilitators have clear and appropriate perceptions on the boarder aim of adult education program. Adequate training should be arranged to facilitators on the mission and operation of the program: content, teaching methods and

assessment of learning outcome.

According to Davis (2005) adult learning method includes procedures for creating a relaxed emotional state, an orchestrated and multi-sensory learning environment, and active learner engagement in the learning process. A relaxed emotional state includes relaxation and breathing exercises, suggestions, and a positive learning atmosphere. An orchestrated environment includes imagery, dramatic readings, instructional videos, and peripherals (posters and visual displays).

Table 4 reveals that adult education outcome is affected by the locality of the learners (his/her learning environment). This means that learning in rural areas is far behind than learning in the urban settings. This is for obvious reason that provisions of facilities are expected to be better in urban areas than in rural areas. This could happen owing to the nature of urban center equipped with resources (human and material) than rural centers. As a result, it is believed that the availably of such centers with the required resources may contribute much to the development of positive attitudes and achievement of learning outcome in the adult education program (Lee, 2001).

In the findings, as revealed in Table 4, the marital status of the learners was one of the factors to determine the overall outcome of the current adult education program (Oumer, 2007). Researches show that delayed marriage increases educational attainment and academic test scores, while surprisingly a range of other adult outcomes such as self-reported health and wellbeing, migration decisions, asset ownership, political participation, attitudes and beliefs are unaffected (Ikamari, 2005).

Along with the above findings, an interview with one facilitators of the West Hararghe zone, Ethiopia was also conducted. As how it is suggested that adult learners have experienced enormous problems that disallow them not to efficaciously take part in the program. Among the most vibrant ones are economic problems and the amount of members that a given family could have. When adults have multiple responsibilities at home, obviously they cannot be attentive in learning. This situation makes them to lag behind in their achievement of the learning outcomes. Accordingly, their experience in adult education program is in consequent to their life compared to their colleagues.

The above extract could be evidence for some of the factors that debilitate adult learning which are linked to the status of the respondents in terms of marriage (and corresponding family size) and the status of economy of the learner.

4. Conclusions

The findings of this research disclosed that the outcome of the adult education program is highly affected by the way adult education is deliberated and the method of assessment employed by adult education moderators. More importantly, the learning outcome of adult learner is determined by the methodological approaches employed by facilitators, who in one way or another plays pivotal role in adult teaching learning process. This would lead us to the conclusions that the methods and assessment procedures employed by adult facilitators have momentous contribution toward the attainment of the adult education program.

Similarly, the research reveals that adult education outcome is affected by locality of the learners (his/her learning environment). This means that the experience the learner had in rural areas is far behind then learning condition in urban settings. In this regard, researchers also agreed that the geographical location of an institution, whether urban, suburban, small town, or rural, is expected to have marvelous impact on success due to the differences in organizational and social environments and the resources available. Although the patterns are not clear, the educational inequities in urban area suggest that large achievement gaps could exist between participants in these institutions and their peers in suburban and rural institutions (Everson & Millsap, 2004). Thus, it is suggested to narrow this gap through recompensing special attention to learning in the rural settings.

An important implication of this study is adults 'opportunities to repeat tasks or to have ideas repeated to reinforce learning and skills. Practice is important in their learning, but should not consist

of tedious drills. In this sense, it is suggested to provide reinforcement by incorporating the same information or skills in a different ways through a variety of activities. To put this into effect, education bureaus, Ministry of Education and training institutions should work together to encourage the training of moderators on learning teaching styles and other assessment techniques as part of continuous professional development itinerary.

Last but not least, identifying these practices may assist in finding ways to further encourage and support adult learner to perform well. The current research shed light on important factors that impact adult learner achievement. Further research needs to be conducted to understand this phenomenon by including other factors like the learning facilities, instructional quality, and moderator- learner communication.

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3. Roles of Indigenous Knowledge (IK) for Sustainable Development and Environment Protection: The Experiences of Gurawa , Tulo and Jarso Districts

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Abstract: This research was aimed at examining the general overview, structure, forms, significances and practices pertaining indigenous knowledge (IK) that surfaced the livelihoods of the community for sustainable development and environmental protection. The IK systems of the local community remains unstudied in the past for various reasons. Yet, emerging from society's deep-seated philosophies, IK with varying forms and functions provide the society with coping strategies in the process of making their life better. The investigations of such knowledge enable us to identify and exploit the statuesque, skills and experiences of the local community and ways of transferring IK systems. The community utilizes IK in preserving and protecting the environment together with it ecological niche. This enhances sustainable development especially at grassroots level. Besides, they cultivate their best practices and disseminate them among various social segments. This research employs descriptive and analytical model from top-down and bottom-up participatory approaches. It mainly focuses on practical skills, knowledge, work habits, experiences and attitudes of societies' secular and sacred practice in social and cultural settings. The research was conducted at the villagers and clan bases in Gurawa, Tullo and Jarso Districts as representative samples of the two Hararghe Zones. Research tools like interview, FGD, document analysis and photographing were used to collect the data and capture the incident. The Oromo terms are written in Afaan Oromo script. The major themes and social significances of the IK of the local community were critically examined in line with the cultural practices, living conditions and specific geographical areas. The exploitation of secular, sacred, folkloric and material genesis of IK assist in communicating ranges of themes on the indigenous community, their worldview, their secular and spiritual thoughts, social functions, folk-wisdom as the tradition has been kept intact to the present time before the advance of modern knowledge (MK) and harmonizing with MK to protect the environment and sustainable development in the current time.

Keywords: Indigenous knowledge (IK); environmental protection; secular and ritual practices; Sustainable development; Heera Gadaa

1. Background

The issues of maintaining sustainable development and environment protection by improving deforestation, land degradation, desertification and other natural and man-made phenomena and activities have been the major topics of debate and the high-ranking agenda especially in this 21st century. Scientists, religious institutions, secular and non-secular organizations, international and charity organizations and media agencies are designing schemes to prevent the environment together with its ecological niches to enhance environmental protection and sustainable development. To do so, they employ both traditional and modern approaches harmoniously to reduce the complex environmental

problems. Unequivocally, various integrated practices of indigenous knowledge with respect to agricultural practices, water supply, soil and land management, wildlife preservation, forest protection and disease controlling mechanisms etc. could greatly improve society's livelihoods and bring about sustainable development.

Most current argument and researchers give more weight to modern technologies as means to bring about development and transformation through the preservation and protection of the environment. They usually leave behind the IK systems of communities or otherwise give less attention to them in spite of their core component and practical outcomes. Nonetheless, different forms of undiscovered IK of a given community play great roles in promoting and enduring developments. They are born in, grown with, and flourished in the framework of indigenous communities as reflections of their long year's cumulative life experiences. Hence, IK systems in general refer to "locally and naturally granted body of knowledge of the indigenous people" (Mapara, 2009:140). The concept 'indigenous people' is used to character people with long-lasting knowledge systems. Such people can be groups, communities, societies or local clans can be identified in terms unique culture and particular geographical areas. Although such people are survived with various forms of enduring knowledge, their knowledge systems remain unrecognized get less public attention due to socio-political, economic and other factors.

IK can be perceived in broad sense covering all sorts of knowledge intellectual, technological, ecological, and medical, and others. They help the community "to attain firmed livelihood in their environment" (UNEP, 2008:6). They specially help the poor people in their day-to-day practices in their socio-cultural, economic and political lives. They assist them as the basis for local decision-making in relation to agriculture, health, natural resource management and other activities (ARWB, 1998: i; UNEP, 2008:4). Unlike MK, IK is not difficult to utilize and promote as it does not seek more time, energy, cost, and specialized technical skilled manpower in utilizing. However, in spite of their greater significances in the day- to- day life of many communities, different forms of IK have been marginalized. As Ocholla (2007:3) stated, this condition has held back their development and integration.

Different communities in African have many well developed innate IK they seek for and rely upon to bring about sustainable developments from many angles and these can be categorized as their spiritual and secular knowledge (Workineh, 2005; Kas, 2008). In Ethiopia we have many of such knowledge possessed by different communities and local clans as long-lasting and diverse forms. Such people use IK systems as the base of devising making, coping strategies to overcome challenges, to protect the environment and to bring about sustainable developments. Many of such knowledge are found at grassroots level among various community and local clans in which there is less probability to study and describe them in such context.

The communities who are living in Hararghe are distinguished in terms of their cultural practices; wisely use of natural resources, the prevalence of mutual engagement and IK systems that affect their life publicly. The existing IK systems of this society include occupational folklore, environmental protection, land management systems, traditional medicine, animal breading system, disease prevention mechanisms and others. However, still thorough investigation has not been conducted by identifying different forms and their functions to promote and transfer these as the best practices.

A decade ago or more, some people of the area moved away and settled in various regions and localities of Western part of Oromia due to environmental change and drought expansion. Putting various indigenous knowledge into use, they evidently showed their best practices that resulted in the quickest progress they have made. Along this line, this research was conducted to identify and describe the IK systems prevailing within Hararghe communities. Attempts were made to present over all views, functions, social significances, themes, structures and others aspects of IK for environmental protection and exploitation of IK for sustainable development which are the major themes to transform community of the area. There is also currently valid evidence observed from the attentions

given by the government to the exploitation of traditions and values systems in mobilizing the society towards various developmental activities for social transformations.

2. Statements of the Problem and Justifications

Sustainable agricultural systems and biodiversity protection through IK is one of the major themes that gained currency in the 1980s.These developments has been noticed together with macroeconomic reform, food security and income generation in response to the financial and ecological problems that have provoked imported high input modern agricultural practices like improved varieties of selected seeds, chemical fertilizers, weed killers and others. As Tesema (2008:127-130) emphasizes, in developing countries, sustainability evolved from a reassessment of the role of IK and practices in such sectors as agriculture, fisheries, natural resources management at the level of a small scale practices. Many other forms of traditional and customary practices assist to improve the livelihood of the people are often proved to be more sustainable than some imported MK systems.

The existence of IK on various aspects and forms are highly diverse. The prominent ones involve complex farming systems, the conservation of land and vegetation, the role of traditional medicine, IK on farming and agricultural practices and ritual centers. Each of them contributes towards environmental protection, land management systems, disease controlling mechanisms etc. Nonetheless, thorough investigations have not been conducted in these areas. Even many prevailing studies seem to focus on modern techniques of agricultural systems and environmental protection scheme without giving due credibility to the enduring IK of the society. Apparently, the use of local farming knowledge and other IK practices have the advantage of improving interactions between man, the land and the environment to promote biodiversity, preservation of indigenous practices for further maintaining and enhancing sustainable developments. As an ultimate goal, under this condition, the environment becomes the most suitable place for all beings.

Contemporary studies on various methods of IK systems are related to agriculture and environment in Oromia in general and Hararge region in particular. This imply that there are often scarce and inadequate scientific works in the area. The written accounts on Oromo IK systems are commonly found to be fragmented, misrepresented and misinterpreted. Hence, they do not properly describe the socio-cultural and socio-economic issues attached to and exemplified through knowledge systems of various community and local clans. In Ethiopian studies, there seems to be a lack of emphasis on IK systems within adequate scientific documentation on occupational folklore, environmental protection mechanisms, land use and management systems, traditional medicine, tradition animal breading system and the utilization of folkloric wisdoms.

In relation to aspects of IK with regard to agricultural practices, in sub-Saharan Africa, Eicher and John (1990:21) states that several experiments have been conducted to refine fertilizer dosages to come up with ways of minimizing the frequency and amount of fertilizer in use while maximizing outputs. The main problem facing farmers is, however, the unavailability of chemical fertilizers and above all inappropriate pricing policies. |They have complained that they get the highest crop yield only for one or two harvest years by using chemical fertilizers and they use selected seeds every year to obtain a sufficient harvest. With each passing year, farmers find themselves pushed to the threshold of bankruptcy by the ever-rising cost of chemical fertilizers. In fact, the high cost of modern farm management practices has caused farmers in many parts of Oromia to state *lafti gubboo barte* meaning "the land has also started to demand chemical fertilizers as bribes" to be productive. This is an analogous to the government bureaucrats of the courts who are accustomed to taking bribes from peasants in order to make a ruling on certain cases. Thus, owing to the ever-rising cost of chemical fertilizers, people have come to regard 'traditional farming' as cheaper as and more sustainable than 'modern farming'. According to Ben-Dror (2008:127), food products from traditional farming systems are tastier and healthier than food items produced with the use of chemical fertilizers and this indicates the need for prioritizing IK.

The dissemination and widely prevalent of MK systems through globalization in the developing world have far largely made the IK systems to be ignored and marginalized otherwise. However, an increasing number of recent studies in agricultural research and development have affirmed the effectiveness of the IK systems in achieving sustainable development (Eicher and Staaz, 1990:44; and Tesfahun, 2004:25-29). Accordingly, in contrasting to the conventional wisdom of agricultural extensionists, the recent studies advocate the indigenous technical and institutional change as the desirable model for more sustainable development.

Concurrently, the other aspects of IK are related to how the indigenous traditional religion, ritual centers and shrines in Hararghe contributed to the preservation of natural vegetation. According to the Oromo environmental ethics-Oromo echo-theology, traditional ritual places are considered as holy center and thus reserved by the local people. This has something to do with preservation of natural environment for sustainable development. Likewise, the traditional medicine collected from local herbs has been contributing as a traditional laboratory that resulted in the existence and conservation of various plant varieties. This issue is also an important theme needs for further identification and investigation in Hararghe regions. Regarding various forms of IK system, there are hardly any works so far conducted. Therefore, there is a need for full-fledged research work in Ethiopia in general and in Hararghe area in particular on the area of IK.

Therefore, in this study attempts were made to shade light on one of the least studied themes in Hararghe , IK, which has multifaceted advantages when integrated with MK systems to realize environmental protection and sustainable development. In this research, theoretical and practical aspects of IK, roles and functions IK were analyzed to uncover the potentially valuable IK preserved by the society as a long-lasting knowledge and wisdom. In relation this, the general objective of the research was to investigate the overview of the various forms of IK that surfaced the livelihoods of the community of the study area for environmental protection and to ensure sustainable development. The specific objectives are to:

1) Identify different forms of IK systems significant in the day to day life of the community,
2) Describe the skills, knowledge, work habits and attitudes of the community towards IK in the realistic social settings, and
3) Explore the systems that the community uses to utilize IK in maintaining sustainable development and environmental protection.

3. Theoretical Consideration

A theoretical framework for the study of IK systems, their assessments and implementation could be achieved from the perspective of local participation for global understanding and implementation that helps to construct a body of IK of a society and local communities. In view of this, both the top-down and bottom-up participatory research approach were used as the model for the analysis of various forms of IK. Hassan (2008:11-12) indicated that this approach helps to integrate local actions for global understanding. He also briefly summarized how the participatory research model is integrated with the two models. He asserted, "Participatory research and development is rooted in the shift in theories from modernization theory associated with top-down technological transfer, to neo-populist theory that advocates for local people participation, which uses bottom-up approaches in research and development".

Indeed, under normal condition both traditional and modern approaches are complementary or one enhances the other. That is why the quotation stresses the need to integrating the IK systems and various forms of practices of indigenous people with standard scientific methods for further understanding of the undiscovered IK. In this view, the assumption behind is the global issues on environmental protection and sustainable development requires the collaborative efforts of local communities which perhaps constituents of the whole and unified knowledge that can bring about global awareness and development.

Therefore, this approach emphasizes that the technological innovation is nothing to do with society's transformation without making attractive their IK systems.

Participatory research model according to AC, Macaulay et.al (1998:4) emerged in 1960's and 70's as a strategy with an intention to include the culture context of the indigenous people in the process of movement for justices that has long practicing in international development settings. One of the major factors for the development of this model was that traditional knowledge has been used inappropriately, out of context, or for financial or professional profit without obvious benefit to the community. Hence, the proponents of bottom-up or local participation approaches present convincing arguments that local people have accumulated wealth of knowledge based on their long-term experiences which complement scientific knowledge in environmental conservation to bring about sustainable development (Hassan,2008:12). Contemporarily, it is understandable that transformation of a nation demands on the roles and practices of indigenous people and local communities for the conservation of natural environment. In the case, participatory research model of integrated schemes of top-down and bottom-up is highly relevant for the analysis of various roles of the indigenous knowledge of the community. Therefore, this model is highly helpful to investigate and document the IK systems of people of various localities.

4. Methodological Issues

It is supposed that different social groups successfully live through utilizing and practicing various forms of IK systems and the related skillful material arts. Based on this reality, the subject of the research took into considerations different stakeholders. These include literate and non-literate peoples, religious and community leaders, leaders in traditional institutions, traditional ritual performers and singers**,** traditional medicine compressors. Meetings and sessions were held with these groups of people and their experiences were shared through elicitation, demonstration, narration, and description about the existing IK. They also explained essences of IK systems of the society and local community as they were and as they are prevailing currently.

The referred groups were accessed based on the recommendations obtained from contact persons on such assumptions like their expertise on knowledge and cultural traditions of the communities, the material or spiritual folklore they actively engage and based on their regular work habits. The communities have been relied up on such features to distinguish themselves as knowledgeable expert in an area of IK systems and ways of promoting them. Since the owner of IK engaging in various practices of such knowledge are limited in number, available cultural experts among the community regardless of their sex, age, social status and education background were considered as source of the data. Besides governmental institutions like municipality, cultural and tourism bureau, education bureau, planning office and public centers like museum, library, archrivals and others service sectors were visited. They all assisted to understand the overall practices of IK, people's awareness of various forms of IK and ways of preserving and utilizing them for sustainable development and environmental protection.

To identify, describe, analyze and document various forms of IK systems as they prevailed or as are prevailing in the current socio-cultural settings of the community understudy, descriptive research approach was employed. Both qualitative and quantitative data can be manipulated through this approach to research. The exploring of IK creation practices usually employs qualitative research approach to describe and interpret the IK practices in the social and institutional settings (ECIS, 2010:12). As the writer pointed, researchers in the area of humanities use descriptive approach not merely as the description of events. They also rely on it as fundamental means to research enterprise and to contribute a great deal toward peoples understanding of the shape and nature of the society. It provides facts about the way things are and can provoke actions. A good description can also provoke the `why' of a research beyond descriptive frontier and extends to explanation. Thus, most data tools would provide good descriptive account on basic IK, their structures and their functions in various socio-cultural settings. Quantitative research method may also be

used in the research process to establish objective knowledge in relation to the view and value of the respondents.

Since relevant primary and secondary sources of data have great importance to the subject under the study, triangulation or mixed method of data gathering tools was employed. Spratt et al (2004:6) stated "with in a single research paradigm, a researcher can be more effective by using triangulation or mixed research methods". To this effect, observation, interview, FGD, document analysis and photographing were used to obtain qualitative data for the research. These tools extensively employed in the collection of pertinent sources on IK systems as highly embedded within and preserved by the society for further analysis and documentation.

The extensive and series visits made to the society and local communities in Eastern and Western Hararge Zones of the study districts enhanced the familiarity and exchange view with various stake holders and actors on IK at their working places and natural environments. The triangulations helped to understand the practical aspects of IK systems, their present and past importance and how the communities maintain them and their feelings on the current state of various forms of IK systems. Knowledgeable informants, elders and other target groups recognized as major actors provided input on IN practices as they support their livelihood, prevent disease, for environmental protection, to nurture their physical and spiritual needs and to enhance sustainable developments.

Information obtained from primary and oral sources were cross-checked with information from secondary sources such as document analysis and literature review. Document analysis was used to interpret meanings and thoughts that incorporate contents and communicative events. In these case different traditional practices, occupational folklore, IK related documents themes were assessed. Each of them may involve various practices and knowledge of the indigenous community to establish or disprove the evidence already at hand from primary sources and literature review. Given many limitations of oral sources which are laden with some kinds of distortions, baffling and overlapping tendencies in explaining different issues, strictly controlled manner was undergone cross-checking with information from primary and secondary sources. In supplementing document analysis, photographing and field note were used. Photographing was used as a vehicle of describing the realistic view of the respondents, the scenery of the area and practical experiences of the indigenous society and local community on the spot while the community put into practice various forms of IK systems. Field note was used to jot down key issue during data collection to capture informal necessary incidents.

Descriptive data were generated both qualitative and quantitative information. Thus, using descriptive approach, the "what?' aspect of IK as extended to the "why?" aspect were used for further explaining the socio-cultural issues and living conditions of the community understudy. The same data were critically analyzed in relation to the socio-cultural settings of the community in question to answer the 'why?' of IK in the immediate social-cultural life of the community.

5. Data Presentations and Discussions

Overview

Under this title, brief overall issues and status of IK of the study area could be explained mainly by elaborating and exemplifying views of the people on IK of the research sites. Apparently, the prevailing IK among the community and the state of their practices are highlighted focusing on their functions, forms, nature, wisdom and experiences of the community. Accordingly, there are six major categorizes of IK identified in the study area. However, they are highly fragmented and even some of them are replaced by the so called MN as in *daagaa* and *sulula*. These major categories include(a) IK on forest and management(b) IK on source of medicine, (c) IK on increasing productivity, (d) IK on environmental protection, (e) IK related to ritual or sacred practices, (f) IK or wisdom on verbal arts. Each form of IK incorporates different specific knowledge and skills in which the members of the community of the study area put into use subconsciously or consciously. They help them to win their lives, to enhance sustainability and to protect the environment from further degradation. Not having mutual exclusive

manner, each forms in the categories have also their own, themes, functions, subcategories and distinguishing features in enhancing sustainable development and environmental preservation.

IK on forest and land management is specifically related to animal raring on small plot of land in the absence of ample grass, wise use of land through crop diversification, tracing as well as intercropping. IK on increasing productivity is exemplified by waste product management and exhaustive utilization of animal manure, rotten lives and other decayed matters to make fertilizer through traditional compost preparation. This IK is more realizable and fruitful than the imported or manufactured fertilizers. The *Qurii* (water collected in the form of ponds) for irrigating plants during dry seasons is also another form. Such practices entered the social life as coping strategy enabling people to survive in dry climate or season resulted from either the prolonged rain drop or the naturally semi-arid and arid areas as parts of people's living style and their adaptive strategies. Different cases on people of the study area also show that the people curiously and carefully use both decay and tradition compost fertilizer justifying that the crop could be tests well and more productive than when they use modern fertilizer.

The IK related to ritual or sacred practices on the Pan *Iituu* and *Humbaanaa* annual *Gadaa* power exchanging ritual which took place at *Odaa Bultum* in the last *Gadaa* cycle and from exploiting the experiences of the community on oral narratives of principles related to the environmental protection. The proclamation and lessons on the stated ritual is highly related with forest and environmental preservation. For example, *Gadaa* ritual practices show that people of the study area widely value the tradition and preserve many types of big trees for their sacredness, place of *Gumii* deliberation and reconciliation. It is believed that part of these natural plants is considered as a houseful to human being, life-giving shade for birds and animals, source of edible fruit for human being and specious of birds and place of tranquility that gives special sense to life.

As the councilor of *Abbaa Gadaa* at *Odaa Bultum* explained in connection to *Baallii* (Gadaa Power Transferring Ceremony), since the revitalization of *Gadaa* and its ritual practice started for the last three *Gadaa* Cycles, the attitudes of members of the communities have been drastically changed towards environmental protections. Thus, together with the *Baallii* ritual takes place per *Gadaa* cycle at *Odaa Bultum*, the proclamation and dissemination of *Heera Gadaa* (*Gadaa* Constitution) and *Heera Bosonaa* (unwritten constitution) to protect forest from the perspective theological ethics to protect and preserve the environment. Of the 20 Major *Heera Gadaa* which is part and parcel of Oromo Indigenous Religion, four of them comprehensively articulates issues of the environment under the *Heera Bosoonaa.* These are yakka *malkaa lagaa*(the violation of norms of river basin), *yakka dirree tikaa*(the violation of norms of meadow) and *yakka fooyyessa dinagdee* (the violation of economic resurgence) (see title 'IK on Ritual and Sacred Practices').

Understanding the economic use of land, member of the community in the study area apply various IK on small farm lands and realize environmental protection in the meantime. On the other hand, one of our informants stated that the elders clearly articulate the manifestation of environmental and forest laws in their culture supported by elaborated *Heera Bosonaa* (unwritten constitution to protect forests). The laws get extended from religious life to secular practices as comprehensive unwritten constitution which has been sustained with the society for centuries. With regard to the management of land, member of the community developed various skills to protect their farm plots from erosion or running water through building terraces in sloppy areas. The construction of ditches and canals around farmer's plots of land significantly protected the washing away of fertile soil, or cultivated fields by flooding. Along these terraces, the community usually plants various species of grasses for lessening erosion.

Daaga and *ciphaa* are also two most slightly different but common mechanisms which are practices for dual purposes i.e. controlling soil erosion and increasing production. In case of *Daagaa,* the digging is involved but in *ciphaa,* stones and pieces of rocks are simply constructed to make cement with the soil that characterizes most of the cultivated fields in highlands. As most topography of the land in Hararghe is characterize by highlands and plateau, people wisely use terraces in sloppy areas in their farming fields. Such terraces are usually constructed at 10 feet distance from each other. Doing so, they usually plant

different species of grasses to check erosion. They dig three meters long in depth to enhance the retention of water and moisture.

People of the area have the knowledge and skills of plant different grasses or trees around their cultivated fields which they think would lessen soil erosion. In fact, such trees contribute to the prevention and control of the washing away of the soil by running water and it is more practical in sloppy areas mainly during rainy season. Related to this, people construct *ciphaa* using rocks or stones with the soil in the farm field. People of different areas are very skilled in using *ciphaa* to prevent the formation of gullies in their farmland after harvest during the dry season. There are also well experienced and skillful people in digging their plots with *dongoraa* (digging tool). As another informant, explained, this exposes the soil underneath to sun heat for different reasons. First, the community thinks it would help to expose the soil to the sun heat and activate free circulation and relaxation of the soil. Second, it would help the soil to retain water or moisture which benefits the crops.

During spring season, the people keep sprinkling animal manure they collected during the whole year on the plots of land they made ready for cultivation to increase productivity. As soon as the crops bore three to four leaves, they dig round the plant. When the crops reached height to one's knee, they farm round the crop using *jabbii*named as *baybaqaa*. This is done to facilitate the percolation of water. They also seed out the weeds. In this way they increase their productivity. Furthermore, crop rotation is one of the strategies used by Hararghe Oromo to lessen the washing away of fertile soil by erosion and flooding. For instance, after the cultivation of maize and sorghum on their fields, farmers prefer to plant wheat and barley which they think would make the soil firm as our informants explained.

Functions of IN and Strategies to Sustain them

The knowhow or cognitive aspect of IN practices in the study area is based on the issues of environmental preservation, land management, forest consecration, increasing of productivity, medication purpose, sacred or religious practices, and verbal arts. Each of these are closely related to the skills emerged from the long year established way of life of the people in the utilization of different forms of IN systems. This again determined in the setting of work habits and living style of the community in their specific geographical and cultural settings. They demonstrate their indigenous skills practically in their day to day survival and utilize different forms of IK systems under different conditions. Sometimes, one form of IK enhances and more integrated with other forms as elaborated in cases below.

Case 1-in preparing the traditional compost, the people first dig a wide excavated hole. Then, they collect waste products like animal dung, weeds, leaves, animal and plant left over and deposited in the holes. They keep storing it from time to time and enhance further fermentation or decayed for about three months or so. Soon, they takeout the decayed traditional compost and make use of it by applying in their farming fields during sowing and crop germination seasons. In this process, they adequately demonstrate things from their critical observation and finally determine when and how to use it in a recycled manner.

Case 2-around the plot of land nearer to a single farmer owns, there are a number of different tree species. Among this, the local community preserves trees like Eucalyptus, *Ejersa, Heexoo*, *Waddeessaa* prior to others for their diverse alternative functions that may be seen in terms of considering parallel usage. For example, to prepare traditional compost, society prefers (*Waddeessaa)* tree than other plant species as the fertilizer from the leftover of this tree species gets most suitable for the intended purpose. Comparing (*Waddeessaa)* tree with that of eucalyptus tree, they argue that there are serious disadvantages of the latter. The crops sowed nearby a eucalyptus tree become extremely unproductive. Its roots also go deep to the surface and absorb ground water causing the surface drought. The leaves drop from the tree and its shadow also never substitutes its lack fertility and other disadvantages when compared to (*waddessaa)* tree.

Case 3- To avoid shortage of farm land and to increase productivity of their crops effect in the best and simplest way, the society applies the knowledge of using variety of crops in a single plot of land in one single season. For example, during the summer season right at the beginning of rain drop, they plough their land and sow potato. Soon after getting harvested potato, they use other varieties of crop like barley and wheat on the same farming land. Moreover, they use intercropping techniques such as the cultivation of Khat (*jimaa)* and sorghum or maize and sorghum or maize and sugar beet or groundnut (*ocholoonii)* in single plot of land.

As observed in the above cases, the community adequately makes use of various interconnected IK either to sustain the environment or increase productivity as parts of their day to day routine. People of each research districts consistently narrate that various forms of IK are highly imbedded within the culture and living situation of the local people. To keep the preservation and sustainability of IK, they forward different strategies. For example, to introduce the IK, an individual and group member works for the dissemination of the new IK to the posterity. They also encourage the owner of IK so that the collaborative efforts of the cultural groups could get oriented, taught or trained by the experts for their current utilization. This can be realized through demonstration, exchanging of the production IK, practically observing etc of various form of IK. Experience sharing has also been found important area of such strategies as observed through interaction done between different village communities. The forms of IK that the community possessed can vary in their geographical setting, in terms of the skills of the people and vitality of IK. They also in their degree of importance for immediate consumption for sustainability, increasing productivity and in terms of promoting and transferring various form of IK as the best practices. Finally, they promote certain kinds of IK and value system of local people during farmer's forum, cultural celebration and festivals. These occasions enhance the means of empowering the community, though sometimes they are used for political conception.

Common forms of identified IK system

The various forms of IK of the study area are presented by describing them in specific settings as parts and parcel of culture of the community. In doing so, the practices of the community are demonstrated supplementing by photographs taken during series of field work activities. As one form of IK in the lists is linked with or raised under one or more forms, the categories of IK are not mutual exclusive. What matters is to make the different forms of IK clear in line with the experience, skills and working habits of the community understudy focusing on the major themes related to the IK identified in each subtitles.

IK on forest and land management

Since the people consider land as the immediate factors of productions and forests as means of survivingall living things, they have rich experiences and indigenous ways of protecting in the changing and continuity process. Regarding the use of forest, the society share their experiences in an interconnected manner whereby we can observe the consequences and outcomes. For instance, the people strongly believe that the disappearance of forests bring about desertification. Conversely, they accept that moisture of the whole days and dew point of the morning and night time are provided from the forests. Similarly, to overcome the problem of grazing grasses for their cattle, people make utilize the tracing edges located between traced lands called *daagaa* along agriculture fields. They also plant grasses and decorate the landscape using stone to protect soil slide as well as the washing away of soil by erosion.

Picture 1. Land Management Skills in Tullo.

The society practices of indigenous soil conservation system seem to be transformed at different periods as indicated by different names. In the former time they used the terms *maagara bishaan hidhuu* in which people used to rely on the concept *ijaan qiyyisuu,* i .e, the art of close observation at the line of eroded land to estimate the line of affected area where they accurately establish tracing. However, later on, such experience in IK gradually replaced by concepts like *daagaa* and *sululaa*. Both concepts are different from *maagara bishaan hidhuu* for applying technology oriented measuring tools to identify and establish the line of eroded land.

On the other hand, to add input to the land for final outcome of increasing production, people systematically use both natural and man-made fertilizers on small farm holdings. Informants underline the importance of their preference of manure than artificial fertilizers for various reasons. First, once the manure is used, it can enhance soil fertility for two or more years whereas the artificial fertilizer can only be used once. When manures are applied to the land only once they could get adequate production for the second harvesting seasons while this is not valid in case of artificial fertilizer. Again, manure is economically more rewarding than the artificial fertilizer whose price is sky rocking. Manure also enriches soil fertility when compared to artificial fertilizers that corrupts the land even upon applying it on the most fertile land. Once the land gets adapted to man-made fertilizer, it cannot give fruitful production without using it persistently. Nonetheless, crops grown using manure can stay for a long period of time when compared to crops grown by fertilizers (Ibrahim, Sufiyan, Najash and Mohammed). Even food products obtained from the former case is said to be tastier than the latter.

Most informants underlined that the use of modern fertilizers could increase the crops physically and help them little to bear more seeds in the process of increasing their production. From their experience many farmers emphasized the greater benefit from applying more manure like animal dung than that of man-made fertilizer to get more production on small plots of lands. Accordingly, the production is greater when natural fertilizers are much more applied to the land and modern fertilizer is applied in small amount. Most informants, thus, agreed the greater the use of modern fertilizers is the more residual than the production expected. Thus, as option, they hold that the more manure and the less the artificial fertilizers they apply on the land is the more production they can obtain. Besides, the Oromo of the study areas employed other forms of IK which directly or indirectly contributed to inputs to land or sustain the environment. Tracing is one of the best methods to keep the washing of fertile soil by running water especially in hill sides or sloppy area.

Picture 2. Erosion break and terraced field in Tullo and Jarso Districts respectively.

IK on source of medicine

The Oromo over Hararghe have preserved various species of trees for medicinal purposes. Such trees range from large species to smaller ones and are found in different climatic zones. Although some of them are found in cool highlands and warm tropical zones, majority of them grew in hot areas. Some of these plant species include: hargeessa, dhebecha, ejersa, baargamoo, hiddiibudee, rummaana, goraa, mi'eessaa, cabbii-tokkee, shukee, jinniraas, ceekaa, harrigoogee, biixxuu, xuuxxoo, baddeessaa, abasuuddaa, xiilloo, adaamii (cactus) and zanjabiil Either the trunks, the leaves, the rots or almost parts of

these plants are used as means of composing traditional medicine. Either the extracts: leaves, stems, roots, fruits, latex or the seeds of these plant species are important for medication purposes. For instance, leaves of eexoo pounded and used as medical purpose to avoid tape worms. The extract of xiilloo is used to pull out the thorns that hide in the skin causing itching. The latex from *adaamii* (cactus) mixed with red xaafii and offered to a mad dog cures through it through vomiting.

IK on increasing productivity

The IK on increasing productivity greatly vary according to experiences of the community in specific settings. Here only the common instances to majority of the people are demonstrated. To begin with, the community widely uses intercropping as one of the most important methods that help them increase production from the land, to diversify their diets, to improve daily consumption and to increase their income. Mostly cereal crops such as barley and wheat are inter-planted with maize, sorghum and other varieties of crops on *jimaa* fields. The people also believe that the dense roots of inter-cropped plants and cereals would firmly hold the soil much so that it would minimize erosion. Besides, the residuals of diverse crops get decomposed and increase soil fertility. Likewise, it is used for fattening cattle as well as protecting the run-off water in the *jimaa* fields. As identified through observation, since the people of the study area support their livelihood by planting *jimaa* on small plots supplementing with fattening cattle, this could have its own role in preserving the forest standing still

Picture 2. Intercropping Practices in Tullo and Gurawa.

Due to population growth and fragmentation of land, majority of people in Hararrghe prefer to grow khat (*jimaa)* than other crops. Specially, most farmers in the highlands where rivers or underground water is often available depend on the cultivation of khat (*jimaa)*. This resulted in the decrease of production of food crops which are expected more from the highlands. The situation is aggravated when khat (*jimaa)* leaves grew longer and cannot allow intercropping. Therefore, with the income they can get from khat (*jimaa)*, many people likely to spend on food crops. To increase their income on small plots, they pull out water from river, springs, dug wells or collect water in the ponds during the summer rainfalls. This would help them alleviate shortage of water for khat (*jimaa)* fields which they usually use during the dry season.

Since getting much crop production requires vast agricultural lands to support one's families, the people of the study area usually devised means of becoming efficient on small plots of land. To do so they make *jimaa* their best choose. This plant requires water to ripe for sale every month. Thus, the people obliged to collect water in ponds and preserve for use during dry season as the most and commonly practiced methods. Its relevance also has entered in social lives to the extent that it become good criteria in the property lists asked by girl's parent upon marriage question of the couples. Thus, if the boy does not possess *qurii* (water collected in ponds), the girl's family refused to allow the marriage. On the other hand, people of the Hararghe in general and that of the study sites in particular are said to be the most hard-working ones. They work day and night to increase *jimaa* production digging its fields sometime using kerosene light during the night. This is because once *jimaa* field is properly planted it would bring income estimated to range between 5000-10,000 birr from 500 square meters land in an average. This illuminates that the Oromo of the study area innovated such efficient strategy which help some to own one or more vehicles of transportation and merchandise goods.

The other important IN for increasing productivity is animal fattening. People of the study area keep separate enclosure for the kind of cattle they want to fatten so as to diversify source of income. They keep nearby home in small hat like ordinary shelter to prevent the long movement of cattle by providing food and water. Early in the morning they take grasses to the cattle in the field and back them to home to prevent them from extreme sun heat. Then, they roasted salts and grind it to feed them. This would enhance the appetite of the bulls for feeding and made them drink more water. It also replaces the advantage that the people used to obtain in the past by taking their cattle to *horaa* (salty springs).The animals are also given different kinds of cooked grains like sorghum, maize, lintels etc. At the same time the cattle to be fatten is made to feed a new ripen crops of sorghum and maize.

Picture 4. Process of cattle fattening in Tullo.

In the fattening process, the people have specific varieties of animals feeding for the morning, day time and the night time similar to the meal they have for people in regular manner. In the morning they provide feeding consists of grinding clay sand mixed with salt. Soon after feeding the cattle, the owned take them to the place where grasses with the morning dew points are preserved. If there is shortage of such grasses, the people use two strategies: (a) the rinsing the stem of the corn with salt and feed them (b), depending on their experience from MK, they plant elephant grasses and use them for the same purpose. In the day time, they usually feed the cattle sugar beet which is the common plant in the area. In the evening, the ripen sorghum, corn and kidney beans are mixed and served for feeding but now they avoid mixing it with the salt to avoid cattle from getting thirsty.

Upon fattening cattle, the Hararrghe Oromo carefully select good species in terms of having long height, wide bones, good appearance and compelling color. To the contrary, they do not fatten short, unattractive color and horny cattle believing that they could not grow well to attract high price. With regard to the place reserved for the cattle, during the night a house with a well leveled floor is preferred to avoid discomfort for the fattened cattle that would lead to a decline in their fatness resulted in attractive and high price

Picture 5. Cattle selected for fattening in Jarso.

People also give serious attention to the issue of quantity versus quality by preferring to fatten few oxen instead of many for various reasons. First, the more they feed a few oxen properly, is the more they can afford economically to feed and sell them in high price that support their lives. Fattening large numbers of cattle on small plots have the disadvantage of creating overgrazing which leads to soil erosion.Thus they believe that fattening a few oxen on small plots permits the use of grazing lands based on shifting system which does not affect proper feeding and this makes the land prone to erosion. According to our informants, Sufiyan and Najash, the Hararghe community used to teach and handed down this IK to the generation orally.

IK on environmental protection

Environment is living place for the entire living beings and it should be seriously protected. Therefore to address the issues of environment, the Oromo of the study area have long-lasting secular and religious lesson to teach about the environment. They usually explain the environment in relation to the forests, the land, the mountains, the valleys, the rivers and hills. They tell and retell about the laws and the connections between their lives and nature which manifested in folk songs, proverbs, riddles, wise sayings, elaborative speech and other folk genres. Various folk genres are expressed at social occasions like *miriysaa*, *darashii*, *shobdoo*, *shagooyyee* and which whose organic data are presented under 'IN on Verbal Art'. Here, the comprehensive and essential IK formulated by *Heera Gadaa (Gadaa Constitution)* to protect the environment is *Heera Bosonaa* (unwritten constitution to protect forests).According to *Gadaa*experts,the protection of the environment is mainly resulted from the preservation and conservation of the forests and various trees species(Sufiyan and Najash).*Heera Bosonaa* is one of the highly comprehensive laws that restrict individual from doing of guilty of cutting forests or damaging the environment. One who act against *Heera Bosonaa* will receive punishment. The person who cut a tree without the consent of his neighbors or elders in the area is fined in cattle like a cow or a heifer or in cash based on the nature of the damage. Yet *Heera Bosonaa* allows cutting only old aged tree species, trees beg into fall down, hooked or curved shape bearing plants lack branches. They perceive that these kinds of tree would hinder the growth of other trees. They are also recommended for fuel

Optimistically, people perceive the shades of trees such as *Odaa* and *birbirsaa* as a life-giving and symbol for many things. First people conduct ceremonies like *wadaajaa/du'aayi* (indigenous ritual synchronized with Islamic practices) under it. Second, the Oromo *Gadaa* system is related highly to the conservation and preservation of environment. For instance, Oromo held various meetings, ceremonies and *gumii* deliberations under *Odaa*. Hence, they preserved it for various reasons. First, it is believed that the branches of *Odaa* are inspired for giving comfort to life. Its shades protect animals, small plants, cereal crops and people from extreme sun heat. When discussing under such big trees, the Oromo believe that it reduces sound echo and do not affect those small plants and cereals grown under it. *Odaa* is also safe from being dwelled by poisonous snakes and predatory animals. Furthermore, Oromo of the study area hold that lighting does not strike the *Odaa.*

As a result, *Odaa* serves as a place of assembly for elders under which they preside over disputes and safely kept cattle to protect them from extreme sun heat of the afternoon. In the past, *wadaajaa* ceremony used to be frequently practiced under large shades trees which they called *hujubaa*(indigenous burial place). To some extent, currently people have preserved *wadaajaa* ritual practice and conducted it at *hujubaa* and Muslim saintly shrines. These places are named the 44 Islamic saints such as Aw Said, Aw Jimjim, Aw Negus, Aw Jibril, Aw Gudora etc. These areas are recognized as places where the people made Islamic pilgrimages to saintly patrons. So, it is a taboo to cut trees, put the land under cultivation, throw pollutants or other thins affect such sacred places. Even for their ceremonies they use only the falling branches or hooked trees which prevent the growth of other trees. Thus, forests and trees represent life under which ritual ceremonies, arbitration, assembly (deliberation)and meeting held on matters related to *gosaa* and *gumii*. The shade of the trees valued as a place for protecting and getting rest their cattle. Due to

such cultural practices, Oromo of the study area have special reverence for forests (Sufiyan, Najash, Mume Ibrahim)

Picture 5. Some species of trees near Oromo ritual sites, Gurawa.

The Oromos also like to settle in areas where *marga jiidhaa* (green and fresh grasses) grow in abundant. *Marga jiidhaa* is attached to symbolic meanings for fertility and perpetuation of life and usually are the means of blessing. Such protective mechanisms are embedded in Oromo culture to the extent that they say until recently 'the earth has mouth, ears and eyes, speaks, listens and sees us while we do everything on it' as of Oromo Concept of Safuu. The Oromo concern for trees and forests is also clearly manifested from the names they give to their sons and daughters. In Jarso and Gara Mul'ata elders stated that the Oromo named their sons and daughters after various species of trees like *qilxuu, birbirsaa, habruu, biqiltuu, Odaa* etc. The equating of children with these trees depicts their desire to protect and care for trees and forests by every individual in the same vein as their children. On the other side, the society also have a wise expression which says, *namni muka dhaabeefi namni dhale maqaan hindhabamu* (Once name who planted the tree or/and who gave birth will never get perished).The ideology of this saying indicates that as the child is named after its father, so the tree could also be named after the one who planted or protected the tree. In the process of generation continuity, the name of the ancestor remains in the genealogy, so the life of the people reveal that too old trees are still remain popularly known.

The Oromo of Harargrge address the importance of preserving growing trees in proverb *muka ol guddataa jiruufi daa'imani ol guddataa jirtu tokko* (A growing tree and growing children who do not complete their development stage are the same). As handled down by elder to the posterity, the communities usually teach the generation so that they seriously consider the role of environment in their lives. This shows the high regard and friendly relation the Oromo have for their environment. They associated trees with human beings showing their awareness about their environment. As a result, they plant trees like podocarpus, *baargamoo, waddeessaa, ejersaa* etc in their farm fields and around the river.

Traditionally the community does not always cut trees as they please them. But if their need arises for fuel and other conceptions, they cut parts of branches in the way they might not harness the growth of the trees. Customarily, cutting the trees in the span of two weeks' time since the appearance of a crescent becomes a full moon is not allowed. They believe the trees get dried totally. It is rather permitted to cut after the end of three weeks after the moon span. Hence, when people want the wood for house construction, they only cut trees two weeks after the crescent appeared thinking that the wood would become dry quickly and brittle easily. Upon cutting trees, people do not usually do deep into its roots. Rather they cut it at some meters above the soil to allow the trees to sprout again from the bottom. Soon after cutting the trees there is a tradition to put animal dung or cover it with the soil on the remaining part to protect it from drying. This would help new trees to sprout out. Generally, the Hararghe Oromos plants trees in separate quarter from farm fields both for their future use and to protect their environment (informants, Sufiyan and Najash)

Ritual or sacred Practices

Even if majority of the Oromo in the study area practice Islamic Religion, their religion seems to be highly synchronized with Waaqeffannaa practices and value systems that indicate they believe in one God. Basically the Gadaa system and Waaqeffannaa are highly integrated. Hence, as people of the area actively practice *Gaada* system, they also practice Waaqeffannaa religious principles side by side with Islamic Religion. For example, they use Waaqeffannaa oriented concepts, blessings, proverbs, proclamations, expressions and other verbal arts in the process of sacred practices or rituals to protect and prevent the environment.

In cursing and blessing, the Oromo of the study area firmly pass advice saying *abaarsa sadeen sodaadhu* (fear the three curses):(a) the deification along the street (b) deification along river side (c) deification under the shade of trees. The harmony and strong interaction between the entire living environments is addressed by five basic praying principles. The principles give equal respects for the God, women and subjects of the environment. These are *Waaqni wayyu* (the God is respectful), *lafti wayyu* (the Earth is respectful), *dubartiin wayyu* (the female is respectful), *gaarri wayyu* (the hillside/mountain is respectful) and *lagni wayyu* (the river basin respectful).

On the other hand of the twenty cardinal *Waaqefannaa* principles, four of them entirely devoted to environmental protection and preservation. The principles also touch many aspects of secular issues and identified as *yakka malkaa lagaa* (violation of norms of river basin),*yakka dirree tikaa* (the violation of norms of meadow),*yakka fooyyessa dinagdee* (the violation of economic resurgence), and *yakka dhaddacha* Oromo (the violation of norm of *Gadaa* Multitude Ritual Assembly)and each are highly elaborative.

According to principles of violation of norms of the river basin, the river basin can be the place where minerals are excavated, cattle drink water or *horaa*, rocks are obtained, and forest and wild bests of societal or public properties are available. Neglecting public ownership, if individuals or groups quarrel on such properties and caused different consequences, it is the violation of norm of river basin. In this case *Heera Gadaa* forces one to pay *gumaa* (indemnity) and punishment upon one's quarreling in using *heelaa* (place of preserved water for cattle), cutting the straight tree or *Odaas* and killing wild animals and pollutes the river. These acts directly or indirectly affect the individual and the society. Hence, the individuals and the society have their own share in receiving compensations.

The violation of principle of economic resurgence is the way of protecting and preserving *waan jiraa* (any form of economy).The society explain this in relation to possible options in moving the nine fortunes. The nine fortunes are:(a) two people-male and female (b) four splintered feet-cattle, sheep, got and camel, (c) three closed feet-horse, donkey and mule). The nine fortunes are named *waan muran dhiigaa harighan fiigaa* (those that run upon chasing and getting bleed upon cutting). The owners of such animals take them to and bring back from the grazing land in orderly manner. For example, one should avoid them to keep in the same fence and the same field just to avoid sudden death. The owner also needs to treat them independently in grazing land, living environment, and the weather condition for breeding them. Traditionally, the society recommends breading sheep, goats, and camels in cool temperature, hot temperature and desert land respectively for their economic use. It is also believed that the brides leave from the right side and come back to home from the left. People towards the market and from the market take opposite direction to avoid unnecessary clash which affects *waan jiraa*. Upon taking the cattle to *horaa* and back from *horaa*, the keeper should use opposite directions for the same reason. If someone leaves a narrow passage for moving the cattle through and built fence, the cattle may run into other animals and harm them by piercing them with their horns or kicking and killing the small ones. In the absences of the above norms, both *jiruu* and *waan jiruu* would be affected.

Generally, *Heera Gadaa* forces the individual who failed to leave ample pass way to pay g*umaa* and compensate for the victims. The village elders, clan leaders, *hayyuuu* (wise person) individuals in the village also compensate the people and the owner of the meadow where the accident happens.

The violation of principle of norms of the meadow is the facilitation of the purging or washing out of the meadow instead protection or keeps the meadow safe. According to oral historian, the concept of violating norms of the meadow first was originated from *saglii* tradition. *Saglii* is the name of nine individuals who were named upon slaughtering animals in a compound to perform *waadaa* in protecting

the meadow. In such traditions, a group of nine people should be together in slaughtering an animal. *Heera Gadaa* forces a group to offer *dirraa* (meat of the rib bone) dividing it into three to three consecutive passengers which may come while the groups is on the blessing ceremony. If another fourth passengers comes and requests *dirraa*, they respond as 'dirreen *nagayaa taatetti* (the meadow has been perfectly in peace) as code of informative. But if the forth person is pregnant women, it is a must to give her equal portion of the meat. If the group fails to do so, the *Gumii* and *Heera gadaa* forces them to slaughter another animal for compensation. Specially, the compensation given to a pregnant woman is quick and very serious as she may get aborted. Besides, people in the *saglii* group care for her until till time of to check the newly born child is normal. But since the *Heera Gadaa* allows *gumaa* starting from birth, the women is not allowed *gumaa* for the aborted fetus. In one's home or meadow, it is a norm to provide the guests with dinner. In the absence of readymade dinner, the family reserves the food they have preserved for the children. People should not throwaway dead animals around one's home, at grazing land and in the open field, there is no open deification. Doing all these is the violation of the norms of the meadow.

The violation of principle of norm of *Daddacha* Oromo (*Gadaa* Multitude Ritual Assembly) related to the harming of big trees like *Odaa, Qilxuu, birbirsa, Dhaddacha*which are mainly considered as *ardaa jila* (ritual site for praying, mediation, *gumaa and gimii* deliberations. It also includes water body, mountain, or *Caffee* (plain area) where people gather and pray, *Waaqaa* discuss different social issues and pass decisions. Such areas are as parts and parcel one's family and give them necessary cares. These mountains are not damaged for the sake of getting mineral, for construction and for other economic or social needs. Forests and big trees are not cut down and streams are not dried up for the same purpose. The people rather care for such areas considering them as means of livelihood. If an individual or a group failed practices these in their locality, it is said that they perform the violation of principle of norm of *Daddacha* Oromo (*Gadaa* Multitude Ritual Assembly)

IK On wisdom or verbal arts

There are different proverbs, elaborative speeches, riddles, expressions and folk songs that the Hararghe Oromo in general and that of the study area in particular address their compatriots the need to preserve, conserve and protect their environment. Generally, different verbal arts are carefully constricted based on the experience and wisdom of the people accumulated over a long period of time in the past and has been perpetuated to the posterity. Hence, they have great impact to influence the people in their day to day life from many angles. Since it is bulky to touch upon every folk wisdom or verbal arts, it is important to consider songs, elaborative speech and expressions.

Traditionally the society use elaborative speech which is used as means of protecting the entire environment in case even when outsiders may try to harm or destroy the environment. The speech runs: *Osoo ka ilkee soddom qabu jiruuti, ka takkallee hinqabne sooftuu fudhatee, 'suwaaka' muruuf gaaratti deemaa kana beekaa*! While one with 30 teeth is there, one who has no teeth picks an ax up and dashes towards the hillside to cut traditional tooth brush, and all of you please have the knowledge of this act! People's concern and respects to plant species like *ejersa*is expressed in songs especially by valuing uniquenessof the plant in its usage.

Way ejersa murittaa	If you cut away an ejersa tree,
Way damee akkam godhittaa	How can you get its brunch anymore?
Way ofii eerumittaa	You are going to get married,
Way ana akkam godhittaa	So, you abandon me,

The lyric song related the significance of tree species to one's best beloved friends in which case it is impossible to get brunch of *ejersa* tree after cutting off it from the base and likewise it is also impossible to

get intimate friend after marriage. The following *mirriysaa* songs similarly address the unique of things including trees among their typical categories.

Muka hunda hin murani	One cannot cut all trees indiscriminately
Muka murantu jira	For we have the kind of species we should cut
Mana hunda hin bulani	One cannot spend at everyone's home
Mana bulantu jira	For one has his own choice to spend
Lammii hunda hinfaarsani	We cannot praise all our compatriot/clans
Lammi farsantu jira	Except those who reputed for their heroic deeds

The first two lines of the verses that are still kept as the common folksong among Oromo of the reveal that every tree species couldn't be cut arbitrarily as it pleases someone and this is a tradition. The verses indicate that there are trees reserved only for use. Tree to be cut, one's home a person can stay the night and person to be braised listed for their parallel uniqueness. As stated before *heera bosonaa* (unwritten constitution to protect forests) limits the use of trees, the kinds of trees to use and under what conditions people they use trees. Furthermore, trees are praised in terms of possessing unique attribute and sometimes attributes that can be compared what human beings as addressedbelow in the *mirriysaa*verses.

Songs in *Afaan* Oromo	**Translation**
Edaa Odaan Bultumi	Oh, *Odaa* Bultum
waa sadi qaba;	it has possessed three things;
Jalaa bishaan qaba	Under the root it has water
gubbaa midhaan qaba	above the trunk it has edible fruit:
Morka dureeysa qaba:	It has attributes to be compared the rich:
Qaamaa shargagga qaba	It has huge physical appurtenance
morka gootaati qaba.	it has charisma to be compared to the hero.

The verses characterize the importance of trees specific to *Odaa* focusing on several functions it can offer to human being. It roots serve as source of water; its huge physical serves as source of shades and tranquility and habitat for animals; its body above the trunk bears fruits useful as diet for, people animals and arboreal habitats animals. The possessing of such things and its huge physical appurtenance make Odaa Bultum the symbolic representation of a rich man and charismatic hero respectively. The verses below also advice people not to cut tree unnecessarily.

Dardarri muka mure	The young man cut a tree
Muka hundeen haddarte	And a tree's root get dried
Abaluu kuma naqeen	Someone has got thousands wealth
Nama gurbeen gargaarte	That has got support of the youth

The first two lines of the verses show the proscription that bans the cutting of trees until the plants reach the stages that it is deserved to cut them for certain purposes. The verse also states that the youth could be the major actors in cutting down the trees as well as in working hard to produce adequate products. This implies the youth age in Oromo tradition and give them awareness as they usually cut the trees to

construct hat, bed, home furniture as well as other the necessary tools in separating from the family and start to establish independent life. There are also *mirriysaa* songs which describe the important of various features of land analogous to real objects that the people depend on to lead their life.

Hallayyaan gaarree lafaa	A cliff is the rift of the earth
Gaarri sangoota lafaa	Hills are like the oxen of the earth
Araddaan dallaa lafaa	Meadow is a fence of the earth
Dhagaan xannacha lafaa	A stone is the gland of the earth
Bishaan imimmaan lafaa	Water is the tears of the earth
Citaan dabbasaa lafaa	The grass is the hair of the earth
Garaan mutaa liqimsee	The abdomen swallowed sharp tools
Qiciicaa lammii tiyyaa	My innocent and kinky compatriots
Akkamiin galee rafaa	How can I back home and sleep calmly?

Except the last two lines of the songs that show one's intention to take revenge on someone for his /her past wrong deeds, all the other lines indicate the importance of forest, stones, water and characterizing the features the unique object i.e. the Earth on which everything relevant to human existence are growing on.

The society also expresses their concerns, belongings and love for big trees having many brunches and the cattle in an elaborative expression '*muka dheeraa dameen dhibba, nama hamaatu saawwan jibbaa*. This implies big trees like *birbirsa, Odaa, gaattiraa, qilxuu* and other branchy trees could be preserved mainly for their grace, home of wild beasts and other functions. The people use similar lyric songs to appreciate the huge nature of big tree, their pleasant smelling, and other economic advantages their functions for the home and shelter for wild animals saying *birbirsa gurguddaa, ija laman ol laaltaa* (you look up the huge *birbirsa* trees with your two eyes), *gaattiraa urgooytuu manaan ijarraa* (you used a pleasant odor *gaatiraa* to build the house), *weennii babbareeduut gubbaarra taphata* (the beautiful Colombes monkey chat on its brunch).

The other useful expressions of advising people for the preservation of natural environment include *lafa lafa ilalte hiqotiin*(one should not till the land form higher than the rest land form) and *lafa waaqa ilaalte qubsumaaf irra hintaa'iin* (one should not settle at the valleys which is lower than other land form).The first expression shows the avoidance of cultivating the hill side or mountain as it contain good moisture and remnant trees species serve as sources of rain and moisture for crops grown in plainly areas. The second expressions show the avoidance of settlement at valley areas as people get vulnerable to flooding or running water.

Challenges, current experience and ways of integrating MK to IK

The currently prevailing high trend of overpopulation seems to serious problem in Hararghe region has forced different members of the society to cultivate marginal land. Due to population pressure, most people have begun to disregard the indigenous way of protecting their environment. There are many instances of cutting various species of trees for house construction and charcoal for fuel wood. Some people in the study area wisely use and protect the environment by planting new trees to replace the used or the one they cut down for different purposes like land management skills (*daga* and*cipaa*), crop diversification and crop rotation and practice of other verbal arts to promote IK. Yet there are many people who are out of necessity or disregard the tradition and indigenous way protect the environment due to lack of awareness on environment ethics which are deep-rooted in various forms of secular, religious and verbal practices of IK. For instances, cutting trees for various purposes, they still could not replace them by new plantings. Parallel with the expansion of agricultural lands, several farmers in *baddaa*

and *badda-daree*areas usually cut trees down for farming. However, there are some sites in Hararghe where natural forests are set aside and protected under the watchful eyes of each district agricultural bureau.

Picture 3. Reforestation and deforestation experiences in Tullo and Gurawa Districts.

The serious and in most cases out of controlling problem that many informant and people of the study district emphasize is the effect of plastic and *jimaa* left over that have polluted the environment. Plastic varieties (high land water container and *mikkaa* /plastic bag) and khat (*jimaa)* by products are strongly attached to the people of Hararge. It is parts and parcel of their culture and so many people widely use them regardless of rural and urban settings during their long journey in the process of chewing *jimaa.* They usually throw away such byproducts into open field, at the edge of farm land, along the bridge and in fact everywhere. There is also hardly any tradition of using the very limited garbage storages properly in urban areas. All these problems are emphasized by experts in different offices of the study area as the most serious problems that affect the environment, productivities and people's health with their other multiplied effects. Generally, there is hardly any well-developed practices of indigenous and modern strategies to manage waste matters especially plastic and byproduct of *jimaa.* On the other various species of trees are reduced due to house construction, use by blacksmiths for charcoal and forest clearing for agriculture in the current time. Although the traditional medicine compressors and bearer of *wadaajaa* ceremony cutsome trees for their necessity, to some extent they preserved them for future use.

Regarding the integration of IK and MK for sustainable development, there remains much to be done. In most cases, the formersare not given due attention as there is a tendency to consider the IN as outdated. Besides, they are not fully exploiting the MK in their daily life because of complicated problems. This proves that if the IK explained above are supported scientifically and incorporated into the modern techniques, they could enhance environmental protection and sustainable development. The result of this is the combination of increasing production on small plots of land without substantial harm done to the environment as verbal songs, elaborative speeches, proverbs, riddles and praise also relate. Although such consciousness is embedded in Oromo tradition, population pressure and the expansion of agricultural lands led to the decline of concern of people for environment. With regard to the wisdom of the Oromo of the study sites they are found to be innovative on the management of land, choice of crops with high market prices and irrigation works and ponds for more production supplanted by animal fattening that increased their revenues and assured their livelihood.

5.1. Concluding remarks

The great deal of knowledge and experiences of people of the world from oral mode of communication have kept persistently perpetuated across the posterity being relied for their long-standing impact in the

daily activities of various communities. Currently, the study of such themes are topical issues that attract the attentions of experts and researchers in various organization, institutions and service providing sectors. It especially highly relied by communities and local cleans of many developing countries as means of livelihood. These forms of IK are highly prevalent among Oromo and other societies who have been entirely depend on oral mode of thought and communication for a long time. This research was aimed at investigating the major forms of IK used by Hararghe Oromo living in Gurawa, Jarso, and Tullo districts identifying their categories or forms, functions, structures, their features as well as the relation of IK to MN. The description and analysis of various forms of IK of the study area highly assist for environment protection and sustainable development independently or being integrated with MK. Various forms of IN entered the social life as coping strategies being part and parcel of people's cultural practices. However, they are not mutual exclusive in spite of their categories, themes, functions, and distinguishing features. Their functions are closely related to the long year established skills, knowledge, experiences &way of life of the people in specific geographical and cultural settings. Each IK incorporates different specific knowledge and skills to help the community to wintheir lives, enhance sustainability and protect the environment. This members of the community demonstrate IK practically in their activities integrating one with the other forms in their secular, religious and artistic life. The *Heera Gadaa* specific to *Heera Bosonaa* and principles of Oromo indigenous religion set laws for protecting environment by preserving forests and trees which represent life under which ritual ceremonies, arbitration, assembly (deliberation) and meeting held on matters related to *gosaa* and *gumii.* The shade of the trees valued as a place for protecting and getting rest their cattle. There is also the basic rules that addresses the entire meadow, rivers and all resources available at the river, Ardaa Jilaa and other subjects of the environment. Due to such cultural practices, Oromo of the study area have special reverence for forests. On the other hand in the context that crop production requires vast agricultural lands, the experiences of *maagara lafa hidhuu, daagaa, qorii,* intercropping, animal fattening are the best practices in which members of the community become efficient on small plots land.

Currently, there is high trend of overpopulation and land fragmentation caused serious problem forcing different members of the society to cultivate marginal land. This problem is found to be the major challenges for environmental protection and sustainable development. Most people also disregard IK in order to protect their environment. But yet, some people wisely utilize them harmonizing MK with MN to enhance environment protection and sustainable development. Others people are neither conscious of IK nor fully exploit MK due to complicated problems in their daily life. Especially the serious environmental problems and pollutions related to plastic varieties and *jimaa* byproducts attaching to the culture of *jimaa* ceremony among Hararghe community are not usually treated using IK. But a few attempts were made using MK especially in urban areas. In spite of some bad instances, there are exemplary works deep-rooted in the secular, religious and verbal arts of the societies contributing to environmental protection and assisting sustainable development. Such practices should be passed to learn by other communities as best practices.

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4 School Related Contextual Factors Affecting PGDT Student-Teachers' Retention Decisions

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Abstract: The paper examines school related factors contributed to Post Graduate Diploma in Secondary School Teaching (PGDT) student-teachers' retention in Eastern Ethiopia. Descriptive survey research design was employed in carrying out this study. Primary data were collected through questionnaire and observation. The secondary data were collected from document reviews. Stratified random sampling technique was employed to select 381 respondents from 987 of the target population. The findings indicated that student-teachers' benefit was the most contributing factors to retain PGDT student-teachers whereas family related factors were the least contributing one. Respect from students, student behaviour, support from school administrators and school safety together were the next four most contributed (83.98%) potential factors to PGDT student-teachers' retentions next to benefits. From stepwise regression analysis, it was found that selecting textbooks & other instructional materials, teaching techniques, disciplining students, and selecting content, topics & skills were the four statistically significant factors contributed 81% to PGDT student-teachers retention whereas the rest 19% were unpredicted variables that contributed to PGDT student retentions. Thus, the object of any organization in general and educational institution in particular is not only to recruit personnel but also to maintain, develop and retain such manpower.

1. Introduction

Contemporary educational theory holds that one of the pivotal causes of inadequate school performance is the inability of schools to adequately staff classrooms with qualified teachers. It also holds that these staffing problems are primarily due to shortages of teachers, which, in turn, are primarily due to recent increases in teachers' turnover and student enrolments. Researches investigate that there are some specified factors that might have an impact on teacher retention levels, and, in turn, the staffing problems of schools, factors rooted in the organizational characteristics and conditions of schools are responsible factors in exaggerating teachers' turnover (Hanushek, Kain, and Rivkin, 2004). Few educational problems have received more attention in recent times than the failure to ensure that secondary school classrooms that are all staffed with qualified teachers. In the early 1980s, a series of highly publicized reports began to focus national attention on the coming possibility of severe teacher shortages in secondary schools (Darling-Hammond, 1984; and Haggstrom *et. al.,* 1988).

Retention is about how an organization manages its workforce or more specifically its relationship with its workforce (Chapman, Synder and Burchfield, 1993). Moreover, Gaynor (1998) defines retention as an action of holding something in position or containing it. Boyd, Donald, Hamilton, Lankford, Susanna, Loeb and James (2005) explain retention as the ability of the school system to keep its staff in their jobs and make them want to stay. There are many factors that may influence teacher retention, which may include a good working environment, attractive remuneration, good relationship practices, prospects for teachers' development and promotion, teamwork, organizational culture and many more.

Mingat (1999) emphasizes that teachers must come to see pay for what it is; just one element in a set of management practices that can either build or reduce commitment, teamwork and performance. When there is poor remuneration, poor school related facilities and poor school administration, the staff morale is low and retention is impossible when opportunities that are more attractive become available; they simply quit. In Eastern Ethiopia, there was terribly no study has been conducted to show the relationship between schools related factors and student-teachers retention. In 2010-2015, the average teacher turnover rate in secondary schools of Eastern Ethiopia was nearly 21 percent ranging from a high of 29 percent to a low of 8 percent (Gemechu, 2014). Generally, the study tried to examine the school related factors contributed to PGDT student-teachers' retention in government secondary schools of Eastern Ethiopia.

2. Purpose of the study

The paper examines the extent to which school related factors contributed to PGDT student-teachers' retention in Eastern Ethiopia. The specific objectives of the study were intended to:

- Pinpoint the way PGDT student-teachers' perceive school related factors to retain them by school administrations;
- Identify the impact of school related factors contributed to PGDT student-teachers' retention in government secondary schools of Eastern Ethiopia;
- Assess the contribution of a school administrator to PGDT student-teachers' retention in government secondary schools in Eastern Ethiopia;
- Show the relationship between school contextual factors and PGDT student-teacher retention
- Make necessary recommendations to alleviate the problem under the study.

3. Review of Related Literature

Three theories explain the problems of staff retention were reviewed in the following subsections: (1) Hierarchy of need theory by Maslows (1959 in Samuel and Daff, 2002); (2) Motivational hygiene theory by Herzberg (1966); and (3) Equity theory by Adams (1965).

Maslow's hierarchy of need theory

Maslow (1943) uses the hierarchy of need theory to explain teacher retention and attrition. According to him people are motivated to satisfy their needs and those needs can be classified into the following five categories that are in an ascending hierarchy. (1) Physiological needs which may include basic salary, workspace, heat, water and company cafeteria; (2) safety needs- security needs which may include job security, benefits like life insurance, safety regulations; (3) belongingness needs such as good co-workers, peers, superiors, customers; (4) esteem needs like important projects, recognition, prestigious office and location; and (5) self actualization needs like challenging projects, opportunities for innovation and creativity training.

Social needs are needs for interaction with other people belongingness, love and so on. These needs reflect the desire to be accepted by one's peers, have friendships, be part of a group and be loved. In the work environment, these needs affect the desire for good relationships with co-workers, participation in work group and a positive relationship with supervisors. Esteem is the desire for respect, which is affected by the person's standing reputation, the need for attention; recognition, achievement, and appreciation can directly or indirectly affect student-teachers' retention.

Herzberg's motivation-hygiene theory

To explain student-teachers' retention, Frederick Herzberg built up the work of Maslow by identifing two elements: Motivators and Hygiene factors. He concluded that factors which seemed to make individual

feel satisfied with their jobs were associated with the content of the job which were labeled as motivators; yet factors that seemed to make individuals feel dissatisfied were associated with the job context which he labeled as hygiene factors. Herzberg argued that two entirely separate dimensions contributed to employee behavior at work. When hygiene factors are devalued, work is dissatisfying. There are considered maintenance factors that are necessary to avoid dissatisfaction but they do not themselves contribute to the jobs satisfaction and motivation of personnel.

In line with Herzberg's view, unsafe working conditions or a noisy work environment would cause teachers to be dissatisfied with their job but their removal will not lead to a high level of motivation and satisfaction. Other examples of hygiene factors include salary, status, security, supervision and school policy. On the other hand, motivators, leading to job satisfaction that is associated with the nature of the work itself. Herzberg argued that when motivators are absent, workers are neutral towards work, but when motivators are present, workers are highly motivated to excel at their work. As Sergiovanni (year, cited in Chapman and Green 1986) and Chapman & Hutcheson (1982) while studying factors, which affect job satisfaction, and dissatisfaction of teachers, came up with the view that the factors which contribute to their satisfaction are achievement, recognition and responsibility while those contributing to dissatisfaction were school policy and administration, interpersonal relationship, supervision and personal life.

Adams equity theory

Adams (1965) uses the equity theory to explain student-teachers retention. Equity theory suggests that employees' perceptions of a working situation in terms of how fairly they are treated compared with others influence level of motivation. Motivation is a consequence of perceived inequity (Adams, 1965). According to equity theory, employees make comparisons; employees determine their own work outcomes versus the effort or input required to achieve the outcomes and compare these with outcomes and efforts of other employees. Education, experience, effort, ability and so on are the inputs factors to the job by the employees that can affect employees' retention. Outcomes that employees receive from a job are also the other factors of employee retention and include basic salary, benefits, promotions and rewards.

Inequity takes place when the situation is reverse, which results into low employee retention for example when an employee with a high level of education or experience receives the same salary as a new and less educated employee. One may perceive it as inequality and is most likely to leave the organization. The implication of equity theory for the organizations is that to motivate employees to stay with the organization, it is necessary to ensure a state of equity in the workplace by establishing mechanism to deal with perceived inequity situations; otherwise, organizations may face high absenteeism and turnover.

4. Materials and Methods

Correlational research design was employed in carrying out this study because it provides an opportunity for the researcher to predict scores and explains the relationship among variables (Creswell, 2012). In correlational research designs, the researcher uses the correlation statistical test to describe and measure the degree of relationship between two or more variables or sets of scores. In this design, the researcher does not attempt to control or manipulate the variables as in an experiment; instead, he relates, using the correlation statistic two or more scores for each variables. Data collected through questionnaire and structured observation checklists from the respondents were subjected to both quantitative and qualitative analysis. The target population for this study consisted of in-service PGDT student-teachers who work in different regions of the country but attending their PGDT courses during summer in Haramaya University, Oromia Regional State, Ethiopia, East Africa.

Population, sample size and sampling techniques

The samples used consisted of 381 PGDT student-teachers out of 987 populations- who teach different subjects (biology, chemistry, physical education, mathematics, physics, English, geography, history, Afan Oromo, and civic & ethical education) and were sampled by using stratified random sampling. This is because firstly, there were different subdivisions in the targeted population which are important to be considered, secondly, there were also variations in population sizes of different strata in this case (sex, ages, experiences and field of specializations) of the populations which were not equal in size. To make the interpretation descriptively easier, the researcher used descriptive statistics (percentages, means, and standard deviation) to summarize the characteristics of the samples. Furthermore, inferential statistics (bivariate correlation, ANOVA and stepwise multiple regression) were used to show the degree of strength & relationship, mean differences among geographical areas and average relationship to predict the most likely value of those variables respectively. This result is significant at $\alpha = 0.05$ level.

5. Results and Discussions

The data obtained from respondents were analyzed using the Statistical Package for the Social Sciences (SPSS version 16). The mean score (M) was used to see the level of effectiveness of respondents on the impact of school related factors. Accordingly, if the computed mean score (M) = 1.00-1.50, it has No Effect; if M = 1.50-2.50, it has a Minimal Effect; if M = 2.50-3.50, it has Moderate Effect, if M = 3.50-4.50, it has Significant Effect, and if M = 4.50-5.00, it has a great deal of Effect.

Table 1. Sex, age cross-tabulation (n_i =381).

Sex	Age in years						Percentage (%)
	<25yrs	25-30 yrs	30-35 yrs	35-40 yrs	>45 ys	Total	
Female	53	26	3	1	0	83	21.79
Male	161	116	14	6	1	298	78.21
Total	214	142	17	7	1	381	100
%	56.17	37.27	4.46	1.84	0.26	100	

As the table1 shows, the majorities (298, 78.21%) of the PGDT student-teachers were male whereas the rest (83, 21.79%) of them were female. From these data one can easily understand that there are gaps between male and female PGDT student-teachers. One finding from this analysis was that these gaps need to be filled to keep equality and equity exists in the teaching-learning processes in Ethiopian secondary schools. The second finding was that the majorities (214, 56.17%) of the PGDT student-teachers were below 25 years. Another finding from this analysis was that most of the PGDT student-teachers were very young adult so that this also provides opportunities for further professional development if they are kept properly in schools.

Table 2. PGDT student-teachers preference where they want to teach and live (ni = 381).

Descriptive Analysis					Summary of ANOVA Table					
Place	Place			Percentage (%)	SV	SS	df	MS	F	Sig.
	Rural	Urban	Total							
Rural	25	45	70	18. 37	Between Groups	0.04	1	0.04	0.10	0.75
					Within Groups	147.18	379	0.39		
					Total	147.22	380			
Urban	19	292	311	81.63	Between Groups	1.18	1	1.20	7.48	0.01
					Within Groups	60.67	379	0.16		
Total	44	337	381	100	Total	61.85	380			
Percentage(%)	11.55	88.45	100							

As it can be seen from the Table 2, the majorities (337, 88.45%) of the PGDT student-teachers were interested to live in urban areas whereas the rest (44, 11.55%) of them were interested to live in rural areas. Moreover, the majory(310, 81.63%) of the PGDT student-teachers wanted to teach in urban areas whereas the rest (70, 18.37%) of them wanted to teach in the rural areas. Besides, the computed F ratio at $\alpha = 0.05$, $F(1, 379) = 0.10$ which was less than the critical region at $\alpha = 0.05$, $F(1, 379) = 3.94$. Hence, it was found that there was no statistically significant mean differences among the PGDT student-teachers who wanted to teach in the rural areas of the country, $F(1, 379) = 0.10$, $p > 0.05$, one tailed. On the other hand, the computed F ratio at $\alpha = 0.05$, $F(1, 379) = 7.48$ which exceeds the critical region at $\alpha = 0.05$, $F(1, 379) = 3.94$. Hence, it was found that there was statistically a significant mean difference among these sampled PGDT student-teachers who wanted to teach and live in the urban areas of the country, $F(1, 379) = 7.48$, $p < 0.05$, one tailed. Additionally, the observational checklist evidenced that most of these respondents were highly interested to teach and live in urban areas.

Table 3. PGDT Student-teachers reason for preference where to teach and live (n_i= 381).

Descriptive Statistics					Summary of ANOVA table					
Why do you prefer where to teach?	Where to teach			Percentage (%)	SV	SS	df	MS	F	Sig.
	Rural	Urban	Total							
1.Because living cost is low	48	92	141	37.01	Between Groups	57.85	3	19.28	15.87	0.00
2. Because there is alternatives of additional job opportunities	9	84	93	24.41						
3.Because student in urban are better	0	84	84	22.05	Within Groups	458.11	377	1.22		
4. Because there are enough conducive environment.	13	51	64	11.78						
					Total	515.96	380			
Total	70	311	381	100						

It is apparent from this table that the majority (141, 37.01%) of the PGDT student-teachers preferred to teach in urban areas because the living cost is low; (93, 24.01%) of them responded that they preferred to teach in urban areas because there was alternatives for job opportunities; (84, 22.05%) of the them responded that they preferred to teach in the urban secondary schools because student in urban area were better than the rural ones whereas the rest (64, 11.78%) of them preferred to teach in either of the two

areas because there were conducive living environments. The most interesting finding from this analysis was that 311, (81.63%) of the PGDT student-teachers preferred to teach and live in urban areas because of the living cost, alternatives job opportunities, better students in urban areas and conducive living environment.

However, the computed F ratio at $\alpha = 0.05$, F (1, 379) = 15.87 exceeds the critical region at $\alpha = 0.05$, F (1, 379) = 3.94. Hence, it was founded that there was statistically significant mean difference among the sampled PGDT student-teachers who preferred to teach in urban areas because of living cost, alternatives job opportunities, better students in urban areas and conducive living environment, $F(1, 379) = 15.87$, $p < 0.05$, one tailed. Additionally, the observational checklist evidenced that most of these respondents preferred to teach and live in urban areas.

Job related factors contributed to PGDT student-teachers retention

From the data in Figure 1, it is apparent that the benefit (117, 30.71%), job security (75, 19.69%), attractive job opportunities (50, 13.12%), job prestige (46, 12.07%), health (38, 9.97%), child rearing practices (26, 6.82%), live in different stage (19, 4.99%), work close to home (9, 2.36 %) and other family or personal reason (1, 0.26%) of the PGDT student-teachers selected from the most important **(**benefits**)** to the least important (family or other personal reasons) as the most influential job related factors contributed to PGDT student-teachers retention in the system.

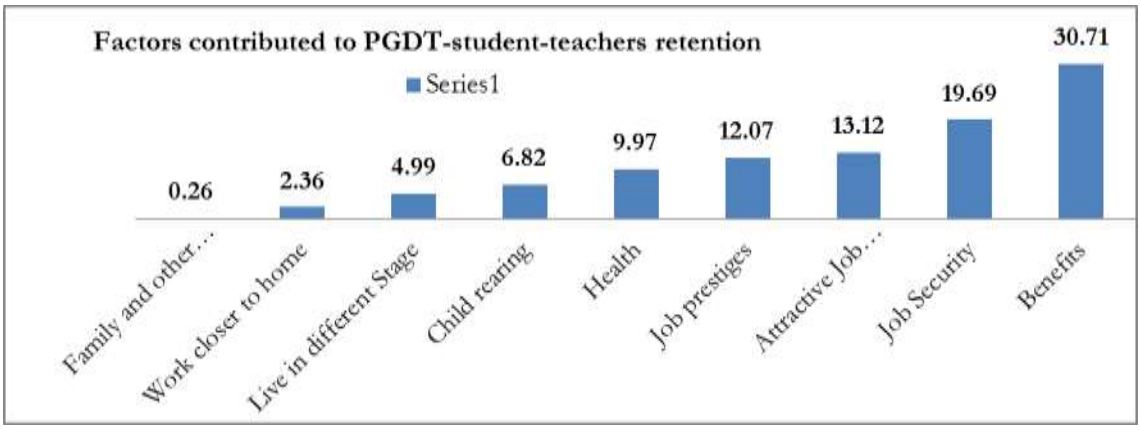

Figure 1. Job related factors contributed to PGDT student-teachers retention.

Table 4. Correlations matrices ($n_i = 381$).

No	Pearson Correlation	Job factors contributing to PGDT student-teachers retention	Status of PGDT student-teachers Retention	Sig.
1	Job related factors contributed to PGDT student-teachers retention	1	-0.150**	0.003
2	Status of PGDT student-teachers retention	-0.150**	1	

As it can be seen from the correlation matrices of Table 4, there was a weak negative relationship between job related factors contributed to PGDT student-teachers' retentions and their status of retention. Therefore, it was found that there was statistically significant negative relationship between job related factors contributed to PGDT student-teachers' retention and the status of PGDT, ($n=381$, $r = -0.150$), $p < 0.05$, two-tailed. Additionally, the observational checklist evidenced that job related factors significantly contributed to PGDT student-teachers retention or aggravating turnover.

School related factors contributed to PGDT student-teachers

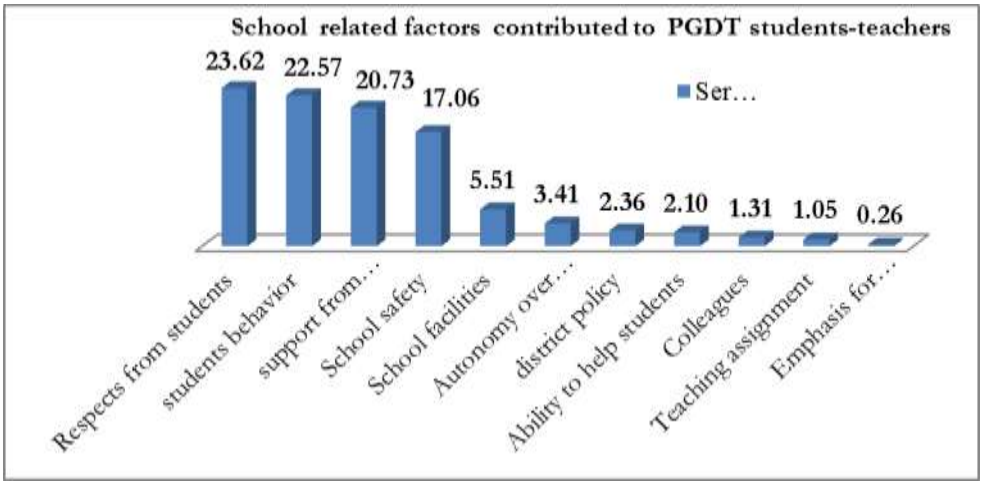

Figure 2. School related factors contributed to PGDT student-teachers.

From the data in Figure 2, it is apparent that the majority (90, 23.62%) of the PGDT student-teachers responded that the respect from students they teach was the most influential school related factors contributed to PGDT student-teachers' retention in the system. Moreover, (86, 22.57%) of the respondents responded that students' behaviour was the second most influential school related factors contributed to PGDT student-teachers retention in the system. Support from school administrators (79, 20.73%), school safety (65, 17.06%), school facility (21, 5.51%), autonomy to classroom(13, 3.41%), school policy (9, 2.36%), colleagues (5, 1.31%), teaching assignment (4, 1.05%) and emphasis for students testing (1, 0.26%) were rated from third to eleventh influential school related factors contributed to PGDT student-teachers retention in the system.

Table 5. Correlation matrices (n_i = 381).

No	Pearson Correlation	Status of PGDT retention	School factors contributed to PGDT Student teachers retention	Sig.
1	Status of PGDT retention	1	0.151**	0.003
2	School factors contributed to PGDT Student-teachers retention	0.151**	1	0.003

As it can be observed from the correlation matrices of table5, there was a very weak positive relationship between school related factors contributed to PGDT student-teachers' retentions and their status of retentions. Therefore, the most important clinically relevant finding was that there was statistically a significant weak positive relationship between school related factors contributed to PGDT student-teachers' retention and the status of their retention, (n=381, r = +0.151), $p < 0.01$, two-tailed. Additionally, the observational checklists were evidenced that school related factors significantly contributed to PGDT student-teachers retention or aggravating PGDT student-teachers' turnover.

Table 6. PGDT student-teacher related factors (n_i = 381).

Descriptive Statistics						**USC**	**SC**	**t**	**Sig.**
Items	M	SD	R	R^2		B	SE	Beta	
					C	2.30			
1.Student-teacher are able to select textbooks and other instruction-al materials	3.58	1.09	0.9	0.81	-0.65	0.06	-0.26	-4.40	0.00
2. Student-teacher is able to select teaching techniques.	3.84	1.07			-0.64	0.06	-0.25	-4.25	0.00
3. Student-teachers are able to be disciplining students.	3.89	0.92			0.76	0.05	0.41	8.88	0.00
4. Student-teacher is able to select content, topics, and skills to be taught.	3.93	0.97			0.59	0.06	0.33	5.90	0.00

As it has been indicated in the Table 6, the computed mean scores (M_1 = 3.58, M_2 = 3.84, M_3 = 3.89 and M_4 = 3.93) of the PGDT student-teachers' responses indicated that they were able to select textbooks & other instructional materials in teaching learning processes, teaching techniques, disciplining students in teaching learning processes, and contents, topics & skills to be taught in teaching learning processes respectively. These indicated that the ability to do these activities in school had a significant effect in retaining them. Moreover, the computed standard deviation (SD_1 = 1.09, SD_2 = 1.07, SD_3 = 0.92 and SD_4 = 0.97) showed us that there were little variability among the respondents.

The most interesting finding from the stepwise multiple regression coefficient (R = 0.90) was that there was a very strong average positive relationship among PGDT student-teachers retention and PGDT student-teachers related factors. These includes the magnitude of selecting textbooks & other instructional materials, selecting their own teaching techniques, disciplining students in teaching learning processes, and selecting contents, topics & skills to be taught in teaching learning processes were contributed 81% (R^2) to PGDT student-teachers retentions; however, the rest 19% (**1-R^2**) were unpredicted variables that were contributed to PGDT student-teachers' retentions.

Table 7. PGDT student-teachers 'administration related factors (n_i = 381).

Descriptive Statistics		**Regression Analysis**								
Items	M	SD	R	R^2	C	USC	SC	Beta	t	Sig.
						1.82	0.32		5.71	0.00
1. The school administration has a well-planned and enforced school discipline policy	3.79	1.03	0. 92	0.85		0.45	0.05	0.12	2.05	0.04
2. Data on student learning are regularly collected and reviewed with all members of the school community (teachers, administrators, etc.)	3.83	1.14				-0.65	0.08	- 0.18	- 3.53	0.00
3. The school administration does a good job of getting resources for this school.	3.85	0.91				0.72	0.05	0.24	5.11	0.00
4. The school administration's behavior toward the staff is supportive and encouraging.	4.13	1.02				0.75	0.05	0.23	5.03	0.00

As it has been indicated in the Table 7, the computed mean score (M_1 = 3.79, M_2= 3.83, M_3 = 3.85 and M_4 = 4.15) of PGDT student-teachers' response indicated that they had a well planned school discipline policy in teaching learning processes(item1), coordinating collected data regularly and reviewed with all members of the school community(item2), organizing a good job in getting resources for the schools(item3) and encouraging administration's behavior toward the staff support(item4). The results of the analyses were indicated that school administrators had contributed a significant effect in the retentions of PGDT student-teachers. Moreover, the computed standard deviation (SD_1 = 1.03, SD_2 = 1.14, SD_3= 0.91 and SD_4 = 1.02) of the scores showed us that there was little variability among the respondents.

The most important clinically relevant finding from the stepwise multiple regression coefficients (R = 0.92) was that there was a very strong positive average relationship between PGDT student-teachers' retentions and school administrations related factors. These include well planned school discipline policy by school administrators, organized regularly collected data on students learning and reviewed with all members of the school community; coordinated doing a good job in getting resources, and the school administrators' behaviour in encouraging and supporting staff were contributed 84.64% (R^2) to PGDT student-teachers retentions while only 15.36%(1-R^2) were unpredicted variables contributed to PGDT student-teachers retention.

Table 8. PGDT student-teachers 'staff related factors (n_i = 381).

Descriptive Statistics			**Regression Analysis**							
Items	M	SD	R	R^2		USC	SC	Beta	t	Sig.
					C	2.52	0.22		11.23	0.00
1. Most of my colleagues share my beliefs and values about what the central mission of the school should be.	3.72	1.05				0.16	0.07	0.164	2.40	0.02
2. I make a conscious effort to coordinate the content of my classes with that of other teachers.	3.80	0.90	0.28	0.0784		0.15	0.08	0.135	1.97	0.05

As the Table 8 reveals, the computed mean scores (M_1 = 3.72 and M_2 = 3.80) of the PGDT student-teachers were responded that most of them shared their beliefs & values about what the central mission of the school ought to be with their colleagues (item) and a conscious effort to coordinate the content of their classrooms with that of other teachers (item2), respectively contributed a significant effect to PGDT student-teachers retention. Moreover, the computed standard deviation (SD_1 = 1.05 and SD_2 = 0.90) of the scores showed us that there were little variability among the respondents.

The key finding from the stepwise multiple regression coefficient (R = 0.28) was that there was a weak positive average relationship between PGDT student-teachers' retentions and staff related factors - sharing their beliefs & values about what the central mission of their school ought to be and being made effort consciously to coordinate the content of their classrooms with their colleagues were contributed 7.84% (R^2)to

PGDT student-teachers' retention while the rest 92.16% (1- R^2) were unpredicted variables in PGDT student-teachers' retention.

Table 9. PGDT student-teachers 'related factors (n_i = 381).

Descriptive Statistics			Regression Analysis						
Items					USC		Beta	t	Sig.
					B	SC			
	M	SD	R	R^2	C 2.58	0.28		9.29	0.00
1. The level of student misbehavior in this school (such as noise, horseplay or fighting in the halls, cafeteria) interferes with instructional activities	3.82	0.99			-0.89	0.06	-0.79	-4.81	0.00
2. I get to know personally many students who are not in my classes.	3.86	1.03	0.93	0.8649	0. 86	0.07	0.79	5.33	0.00
3. My students receive a lot of support for learning outside of school	4.05	0.85			0. 99	0.05	0. 99	3.81	0.00

As Table 9 depicts, the computed mean scores (M_1 = 3.82, M_2 = 3.86 and M_3 = 4.05) of the PGDT student-teachers were responded that the level of students misbehavior in their schools, the attitudes & habits that they brought to classrooms-, reduced chances for academic success-, and knowing students who were attending their classes, respectively havesignificant effect on PGDT student-teachers retentions. Moreover, the computed standard deviation (SD_1 = 0.99, SD_2 = 1.03 and SD_3 = 0.85) of the scores showed us that there was almost consistency among the respondents. Another key finding from the stepwise multiple regression coefficient (R = 0.93) analysis was that there was a very strong positive average relationship between PGDT student-teachers' retentions and students' related behavioural factors**,** the attitudes & habits they brought to classroom and knowing students who were in their respected classes was contributed 86.49% (R^2) in PGDT students-teachers retention while only 13.51% (1- R^2) were unpredicted variables that contributed to PGDT student-teachers' retention.

Table 10. PGDT student-teachers 'facility related factors (n_i =381).

Descriptive Statistics			Regression Analysis							
Items						USC		Beta	t	Sig.
						B	SC			
	M	SD	R	R^2	C	4.14	0.204		20.27	0.000
1. My school has quiet spaces for teachers to work when they are not teaching	3.82	1.01	0.116	0.014		-0.12	.052	-0.12	-2.28	0.023

As Table 10 depicts, the computed mean score (M = 3.82) of the PGDT student-teachers were responded that their schools had quiet spaces for teachers to work with (item1) was found to be a significant effect their retention. Moreover, the computed standard deviation (SD = 1.01) of the score showed us that there was a little variability among the respondents. Moreover, the stepwise multiple regression coefficient (R = 0.116) indicated that there was a very weak average relationship between school related facilities and PGDT student-teachers retentions. Hence, it could be found that school facilities contributed only 1.40% (R^2) to PGDT student-teachers retention whereas the rest 98.60% (1- R^2) were unpredicted variables that contributed to PGDT student-teachers retention.

Table 11. PGDT Student-teachers 'safety related factors (n_i = 381).

Descriptive Statistics					**Regression Analysis**					
Items	M	SD	R	R^2		USC	SC		t	Sig
						B	Beta			
					C	2.75	0.21		13.43	0.00
1. A student from this school has threatened to injure you.	4.05	1.04	0.87	0.7569		0.23	0.05	0.24	4.77	0.00

As the table11 depicts, the computed mean score (M = 4.05) of the PGDT student-teachers were responded that students' physical attack was found to be a significant effect on PGDT student-teachers retention. Moreover, the computed standard deviation (SD = 1.04) of the score showed us that there was a little variability among the respondents. However, the stepwise multiple regression coefficient (R = 0.87**)** was showed us that there was a very strong positive average relationship between student related safety and PGDT student teachers retention. Hence, it could be found that student related safety factor contributed 75.69% (R^2) to PGDT student-teachers retention whereas only 24.31% (1- R^2) were unpredicted variables that contributed to PGDT student-teachers retention.

5.1. Conclusions

From the abovementioned findings, the researcher drew the following conclusions:

- From the sampled PGDT student-teachers 78.21% of them male whereas only 21.79% of them were females. From these data, one can conclude that there are gaps between male and female PGDT student-teachers that need be filled to keep the gender balance in Ethiopian secondary schools. Moreover, 56.17% of them were below 25 years old and 79.27% of them served below 5 years, were very young adults.This provides opportunities for further professional development if they are properly kept in schools.

- 88.45% of the PGDT student-teachers were interested to teach and live in urban areas whereas only 11.55% of them were interested to teach and live in rural areas. Moreover, 81.63% of the PGDT student-teachers were highly interested to teach in urban areas whereas only 18.37% of them were interested to teach in the rural areas. Besides, it was concluded that there was no statistically significant mean difference among these PGDT student-teachers who wanted to teach and live in rural areas, but there was statistically a significant mean difference among these PGDT student-teachers who wanted to teach and live in urban areas of the country. It was also concluded that the reasons why 81.63% of PGDT student-teachers preferred to teach and live in urban areas were having low living costs, alternatives job opportunities, better students and conducive living environment.

- The job related factors contributed to PGDT student-teachers retention from most to the least important were benefit, job security**,** attractive job opportunities, job prestige, health related factors, child rearing practices, life in different stages, work closer to home and other family or personal reasons. From the correlation analysis, it was also concluded that there was statistically significant weak negative relationship between job related factors contributed to PGDT student-teachers' retention and the status of retention.

Respects from students, students' behaviour, support from school administrators, school safety, school facility, autonomy over classroom, attractive school policy, colleagues, teaching assignment, and emphasis for students testing were the most influential school related factors from the most important to the least important school related factors contributed to PGDT student-teachers retention. Moreover, from the correlation analysis, it was concluded that there was statistically very weak positive significant relationship between school related factors contributed to PGDT student-teachers' and retentions. Furthermore, selecting textbooks & instructional materials, selecting teaching techniques, disciplining students & selecting contents, topics and skills to be taught in teaching-learning processes were contributed 81% to PGDT student-teachers retention; however, only 19% were unpredicted factors that were contributed to PGDT student-teachers' retentions.

- Well planned school discipline policy by school administrators, regularly coordinated data collected and reviewed students' data with all members of the school community, well organized job in getting resources, and the school administrators' behaviour in encouraging and supporting staff were contributed 84.64% to PGDT student-teachers retention while only 15.36% were unpredicted variables were contributed to PGDT student-teachers retention. On the other hand, sharing beliefs & values about what the central mission of the school, and being made effort consciously to coordinate the content of their classrooms with their colleagues were contributed only 7. 84% to PGDT student-teachers while the rest 92.16% were unpredicted variables contributed to PGDT student-teachers' retentions. Besides, school facilities were only contributed 1.40% to PGDT student-teachers retention whereas the rest 98.60% were unpredicted variables contributed to PGDT student-teachers' retention. Finally, students' physical attacked on PGDT student-teachers was contributed 75.69% to PGDT student-teachers retention whereas the rest 24.31% were unpredicted variables contributed to PGDT student-teachers retention.

5.2. Recommendations

From the conclusions made so far, the researcher drew the following recommendations:

- There is a definite need for the concerned stakeholders to be aware of balancing and closing the gender disparities among Ethiopian Secondary Schools to keep equality and equity of gender difference in teaching-learning processes. Moreover, it would be recommendable to retain these teachers in schools for further professional development as they were very young adult.

- Almost all the sampled PGDT student-teachers preferred to teach and live in urban areas because of conducive living environment, other extra job opportunities, better accessibility of accommodations and better students' performance. Therefore, it would be advisable to the stakeholders to critically aware these student-teachers to be assigned in rural areas as it is sometimes obligatory and they have to be made themselves ready enough to accept this reality. Therefore, Ministry of Education should consider special benefits that might compensate them to improve student-teachers retentions.

- Good governance is an issue that cuts across teacher recruitment, retention and assignment. Therefore, the education stakeholders, at any level, should ensure good governance

- In school administration, the head teacher and staff must see the need of working together as a team for the growth and development of the learner. The head teacher should understand that the morale of teachers is affected by both materials and human factors. Material factors include salary, sick leave, medical care, equipment, supplies and facilities. Teachers who are not paid for two or three months remain demoralized and can even leave the school if such needs are not met. Thus, school administration should consider such things to retain PGDT student-teachers' retention.

- Finally, the ultimate objective of any organization in general and educational institutions in particular is not only to recruit personnel but also to maintain and develop such manpower in the institutions. Educational stakeholders, therefore, ought to put in place effective manpower retention mechanisms to regain staff.

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