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POTASH ALUM FROM SCRAP METAL CANS

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ABSTRACT

Solid waste management is a global problem with Kenya not excluded. Drainages and sewers are clogged while the air is polluted from the hazardous fumes produced from industrial chimneys even on broad daylight. Metal waste ranks the fourth highest in Kenyan waste after plastics, polythene bags and papers. Modern societies have concentrated on what might be considered the most primitive methods of solid waste disposal which include burning and burying. Since they cannot corrode easily, these waste take several years in the soil. This behavior is a strange anomaly, because solid waste is probably the oldest of man's pollutants and still a challenge to today's Kenya. Initially, Aluminium cans have been recycled to make other cans, but there is a challenge in the amount of energy used. With the challenge of electricity in our country, survival becomes a hard nut to crack. Therefore the study came up with a chemical method of converting waste Aluminium cans into "Potash Alum". The general objective of this study was to recycle Aluminium metal cans into Potash Alum. The specific objectives of this study were: to determine the significant loss of mass in our proposed Aluminium recycling process; to investigate the relationship between the original raw Aluminium piece versus the recycled product and to provide a simpler method of producing Alum. The study aimed at producing an important product from this waste product. This study used a chemical process which transforms scrap Aluminium cans into a useful chemical compound, potassium Aluminium sulphate dodecahydrate, $KAl(SO_4)_2.I_2H_2O$, commonly called "Alum". From the study conducted, it was concluded that scrap Aluminium is one of the leading metal waste in Kenya. The study also concluded that we never truly recycle the entire mass, some are lost to reactions and abrasion an example in filing to get that smooth shinny Aluminium look. It was also concluded that as the quantity of Aluminium used increases, the quantity of Alum produced also increases. It was also concluded that the time taken to produce Potash Alum depends on the method of producing it. It is observed that the proposed method takes the least time in producing potash Alum. In future, the innovation will involve other Aluminium waste products different from cans. The researchers look forward to developing a machine that will easily remove the paints on the cans and cut the sheets into smaller pieces which will be easily reacted. The researchers recommend this project for further research and improvement, so that there is no waste from the project. All the products produced like hydrogen can be harnessed and used. Pollution and unemployment are perhaps the top of the list in Kenya's emerging issues among food shortage and others. By recycling Aluminium and its adoption we create jobs which helps Kenya improve its gross domestic product (GDP). In doing so we will also curb rural to urban migration since Aluminium can be found almost everywhere and industries can be delocalized. This eventually improves the general aesthetics of the land.

***Index Terms* – Potassium Aluminium sulphate dodecahydrate, Scrap metal wastes, recycling.**

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

The Kenyan vision 2030, launched in the year 2008, aims at transforming Kenya into a middle income country from the current third world state. It is in the extent of the context of the vision to recognize a clean and safe environment to all. Efficient waste management system are required as the country develops into a newly industrialized state by 2030 (Bernard, 2013). In this regard, the vision 2030 set flagship projects for the five cities in Kenya to have fully functional and compliant waste management system by developing strategies that will recycle and reuse waste for environmental conservation (NEMA, 2014). Changing consumption patterns, economic development, changing income, urbanization and industrialization results in increased generation of waste. Williams (2002) admits that waste generation will continue to rise. In Kenya, the challenge of solid waste management is real (Gakungu, 2011).

Fig 1.1 Scrap metal wastes

Collection systems are inefficient and disposal systems are not environmentally friendly (Bernard, 2013). Aluminium can waste is among the solid waste. Change in lifestyle has led to beverages like sodas, energy drinks and alcohol to be packed in Aluminium cans (George, 2016). Studies show that the use of cans in packaging beverages is increasing because Kenyans adopt to fast foods; they want food and drinks they can easily carry along (Gakungu, 2011). Aluminum metal has been used because it is the most abundant metal on earth and which also withstand corrosiveness (Van Linden, 1990). Aluminum was first used in cans for drinks in 1965. But it was not until 1985 that aluminum cans were the can of choice in the beverage world, according to the can manufacturing institute.

Because aluminum can easily be molded, it has made it possible for more marketable advertising of products right on the cans (Rosel, 2005). Perhaps the most critical element in the aluminum can`s market success was its recycling value (Van Linden, 1990). There is no difference in virgin Aluminium or recycled Aluminium, yet it takes 20 times less energy to produce it. According to the A to Z of materials website, Aluminum recycling was not only economical for manufacturing companies. However, it is also important to recycle aluminum cans to produce other products that add value (Russell, 1999).

1.2 Statement of the Problem

Modern societies have concentrated on what might be considered the most primitive methods of solid waste disposal which include burning and burying. This behavior is a strange anomaly, because solid waste is probably the oldest of man's pollutants and still a challenge to today's Kenyan (Rosel, 2005).

Aluminium is the third most abundant metal and element in the earth's crust (Bernard, 2013). This is why most of the beverage manufacturers are using it in making packaging cans. However, this cans pose a challenge to the environment when disposed. Since they cannot corrode easily, these waste take several years in the soil. Initially, Aluminium cans have been recycled to make other cans, but there is a challenge in the amount of energy used. It takes 100 watts of energy, enough to light a bulb for six hours to recycle one Aluminium can (George, 2016). With the challenge of electricity in our country, survival becomes a hard nut to crack. Therefore the study came up with a chemical method of converting waste Aluminium cans into "Potash Alum".

Fig 1.2 Metal pollution problem in a forested area

1.3 Research Question

How can Aluminium cans be recycled to produce a different product of value different from the normal current products?

1.4 Research Hypothesis

The challenge of recycling Aluminium metal has led to accumulation of the metal waste in the environment, therefore posing serious solid waste management challenges.

1.5 Aims and objectives

The general objective

- To recycle Aluminium metal cans into Potash Alum.

The specific objectives

- To determine the significant loss of mass in our proposed Aluminium recycling process.
- To investigate the relationship between the original raw Aluminium piece versus the recycled product.
- To provide a simpler method of producing Alum

1.6 Research Variables

- In general, the cycle number is the independent variable as it determines the kind of mass we will get before and after recycling. The masses shift as per the cycle number making them the dependent variables.

- In this study, the independent variable is the current method of recycling Aluminium which consumes a lot of energy, therefore slow and leads to accumulation of Aluminium waste in the environment. The dependent variable is the accumulation of Aluminium waste leading to serious environmental challenges.
- In this study, the dependent variable is the time taken to produce Alum while the independent variable is the method of producing Alum

1.7 Assumptions

- Metal waste is among the solid wastes posing a challenge but receiving little attention.
- The existing method of recycling Aluminium waste is not effective, leading to accumulation of the waste into the environment.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter presented literature review that is concerned with how Aluminium waste poses challenges to the environment and how it has been difficult to recycle it.

2.2 Aluminium

George (2016) conducted an empirical review on Aluminium. The researcher noted that it is a chemical element in the Boron group with the symbol Al and atomic number 13. It is silvery white, soft**,** non-magnetic ductile metal. Aluminium is the third most abundant element in the earth's crust (after oxygen and silicon). It is also the most abundant metal. Aluminium makes up about 8 percent of the crust by mass, though it is less common in the mantle below. Aluminium metal is so chemically reactive that native specimens are rare and limited to extreme reducing environments. Instead, it is found combined in over 270 different minerals (Bernard, 2013). The chief ore of Aluminium is Bauxite. Aluminium is remarkable for the metal's low density and its ability to resist corrosion. Through the phenomenon of passivation. Aluminium and its alloys are vital to the aerospace industry and important in transportation and structures such as building fences and window frames.

2.3 Aluminium waste

NEMA (2014) conducted an empirical review on Aluminium. The researchers noted that the demand for Aluminium products is growing steadily in the Middle East and Africa because of their positive contribution to modern living. Aluminium finds extensive use almost across all values of life including transport, food, medicine, packaging, construction, electronics and electrical power transmission. In fact, the use of Aluminium exceeds that of any other metal except Iron. Aluminium is the second most widely used metal whereas the Aluminium can is the most recycled consumer product in the world.

2.3 Disposal woes and Recycling Potential

Bernard (2013) conducted an empirical review on Aluminium. The researcher noted that Disposal of Aluminium wastes is a challenging task as Aluminium exposed to fires at dumpsites can be a serious environmental problem in the form of poisonous gases and mosquito breeding. Recycled Aluminium can be utilized for almost all applications, and can preserve raw materials and reduce toxic emissions, apart from significant energy conservation. Aluminium has a high market value and continues to provide an economic incentive to recycle it. The excellent recyclability of Aluminium, together with its high scrap value and the low energy needs during recycling make Aluminum lightweight solutions highly describable. The contribution of the recycled metal to the global output of Aluminium products has increased from 17 percent in 1960 to 34 percent today and is expected to rise to almost 40 percent by 2020. Global recycling rates are high, with approximately 90 percent of used beverage cans collected.

Williams (2002) asserts that Aluminium does not degrade during the recycling process. Since its atomic structure is not altered during melting. Aluminium recycling is both economically and environmentally effective as it requires a lot less energy to recycle them than it dies to mine, extract and smelt Aluminium ore. Recycled Aluminium requires only 5 percent of the energy used to make primary Aluminium and can have the same properties as the parent metal. However, in the course of multiple recycling, more and more alloying elements are introduced into the metal cycle. This effect is put to good use in the production of casting alloys, which generally need these elements to attain the desired alloy properties.

2.4 Related systems.

(Gakungu, 2011) notes that Aluminium has been recycled in the UK since the metal first began to be used commercially in the opening decades of the 20th Century. Since that time a large number of secondary refiners have been established, converting new and old aluminium scrap into foundry ingot, deoxidizer for the steel industry and master alloys. Good quality scrap, particularly of the wrought alloys, is recycled back into extrusion billet and rolling slab for the production of extruded and rolled products. There are very good commercial reasons why this recycling has always taken place. The high intrinsic value of aluminium makes recycling economically attractive. Aluminium and its alloys can be melted and recast repeatedly without loss in quality with today's technology.

According to George (2016), the recycling of good quality aluminium scrap back into new ingot takes place with an energy saving of 95% of the energy required to produce the same weight of aluminium through the primary smelter route. Thus, recycling saves raw materials and energy, reduces emissions and also reduces the demand on landfill sites.

CHAPTER THREE

METHODOLOGY

3.1 Requirements

- 250ml flask
- Funnel
- Beaker
- Waste Aluminium can
- Pair of scissors
- Potassium hydroxide solution (4 M)
- 6M Sulphuric acid
- Ice bath
- Ethanol
- Source of heat
- Steel wool

3.2 Procedure

- Clean the Aluminium can with steel wool and cut into very small pieces.
- Put the small pieces of Aluminium (about 1.00g) into a conical flask and add about 50 ml of 4M KOH solution to dissolve the Aluminium.
- The flask may be heated gently in order to facilitate dissolution. Since during this step, hydrogen gas is evolved, this step must be done in a well-ventilated area.
- Continue heating until all the Aluminium reacts.
- Filter the solution to remove any insoluble impurities and reduce the volume to about 25 ml by heating.
- Allow the filtrate to cool. Now add slowly 6 M H_2SO_4 until insoluble $Al(OH)_3$ just forms in the solution.
- Gently heat the mixture until the $Al(OH)_3$ precipitate dissolves.

- Cool the resulting solution in an ice bath for about 30 minutes whereby Alum crystals should separate out. For better results, the solution may be left overnight for crystallization to continue.
- In case crystal do not form, the solution may be further concentrated and cooled again.
- Filter the crystals from the solution using vacuum pump. Wash the crystals with 50/50 ethanol-water mixture.
- Continue applying the vacuum until the crystal appear dry.
- Determine the mass of Alum crystals.
- Mass of Aluminium metal= 1.00g
- Mass of Potash Alum= 1.49 g
- Theoretical yield of potash Alum= 0.49 g

Percentage yield= 49%

Aluminium metal is treated with hot aqueous KOH solution. Aluminium dissolves as potassium aluminate KAl $(OH)_4$ salt.

$$2Al\ (s) + 2KOH\ (aq) + 6H_2O\ (l) \longrightarrow 2KAl\ (OH)_4\ (aq) + 3\ H_2\ (g)$$

Potassium Aluminate solution on treatment with dilute sulphuric acid first gives a precipitate Al $(OH)_3$ which dissolves on addition of excess H_2SO_4 and heating.

$$2KAl\ (OH)_4\ (aq) + H_2SO_4\ (aq) \longrightarrow 2Al\ (OH)_3\ (s) + 2\ H_2O\ (l) + K_2SO_4\ (aq)$$

$$2Al\ (OH)_3\ (s) + 3H_2SO_4\ (aq) \longrightarrow Al_2\ (SO_4)_3\ (aq) + 6H_2O\ (l)$$

$$Al_2\ (SO_4)_3\ (aq) + K_2SO_4\ (aq) + 24H_2O\ (l) \longrightarrow 2KAl\ (SO_4)_2.2H_2O\ (aq)$$

3.3 Precautions

- Ensure that the paint on the Aluminium cans are cleaned out before the reactions.

- Measure the initial Aluminium used in order to determine the percentage yield at the end.
- Wear protective cloths.

3.4 Limitations and constraints

Since we are students, we have little time to experiment on other Aluminium products different from beverage cans.

3.5 Merits

- Does not consume a lot of energy
- Aluminium cans are easily available.
- It's a simple method of obtaining Potash Alum rather than excavating and mining.

3.6 Demerits

It is complex and requires a lot of chemical knowledge and skills.

3.7 Effect of change on parameters

The parameter to be considered in this project is the amount of Aluminium metal used at the end.

Fig 3.1: Scrap Aluminium beverage cans

Fig 3.2: Alum from Scrap Aluminium beverage cans

CHAPTER FOUR

DATA AND DATA DISCUSSION

4.1 Data Collection

In the recycling process we investigated the mass of the source of Aluminium ore and the mass of recycled Aluminium to determine the efficiency for our recycling process. Mass measurements were taken before and after using weighing scales as shown below in various recycling cycles: Data was also obtained by primary experimentation method.

4.2 Data Analysis

Cycle number	Mass of source Aluminium in grams	Mass of recycled Aluminium in grams
A	128	119
B	1324	1218
C	56	53

Table 4.1: Mass of source Aluminium and recycled Aluminium (grams)

The general observation is that we never truly recycle the entire mass, some are lost to reactions and abrasion i.e. filing to get that smooth shinny Aluminium look. In general, the cycle number is the independent variable as it determines the kind of mass we will get before and after recycling. The masses shift as per the cycle number making them the dependent variables. However, the lost mass is insignificant and does not negate the entire process' value.

The graph below gives a better comparison correlation:

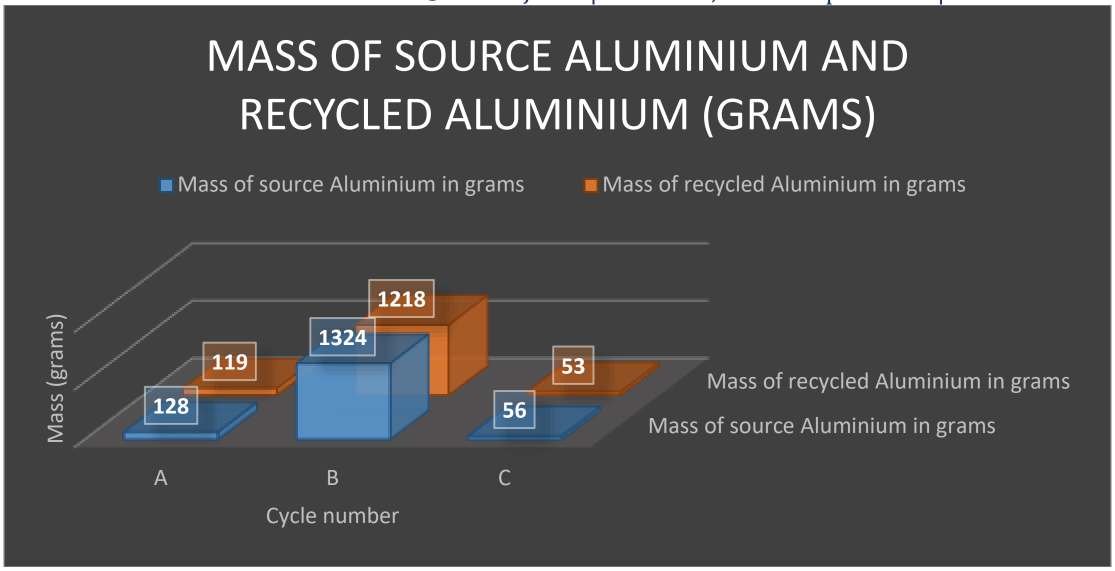


Fig 4.1: Mass of source Aluminium and recycled Aluminium (grams)

Quantity of Aluminium (g)	0.00	1.00	2.00	3.00	4.00	5.00
Quantity of Alum (g)	0.00	1.49	2.98	4.47	5.96	7.45

Table 4.2: Quantity of Alum produced during experimentation

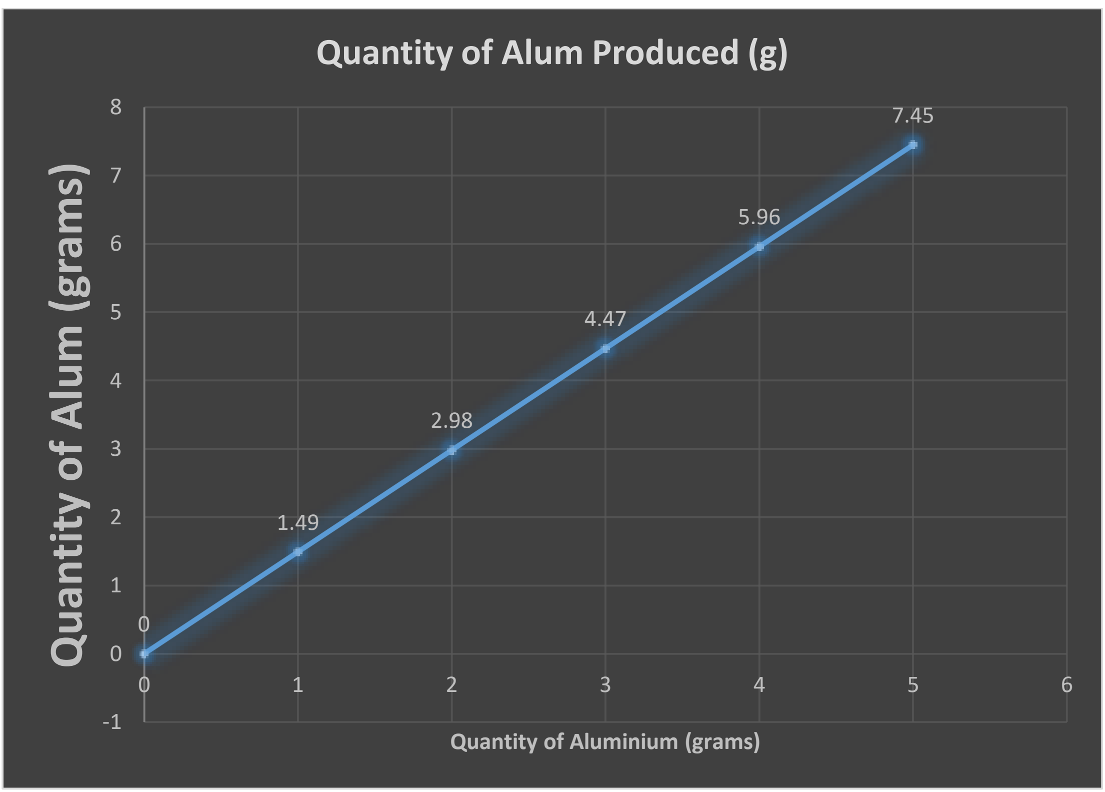
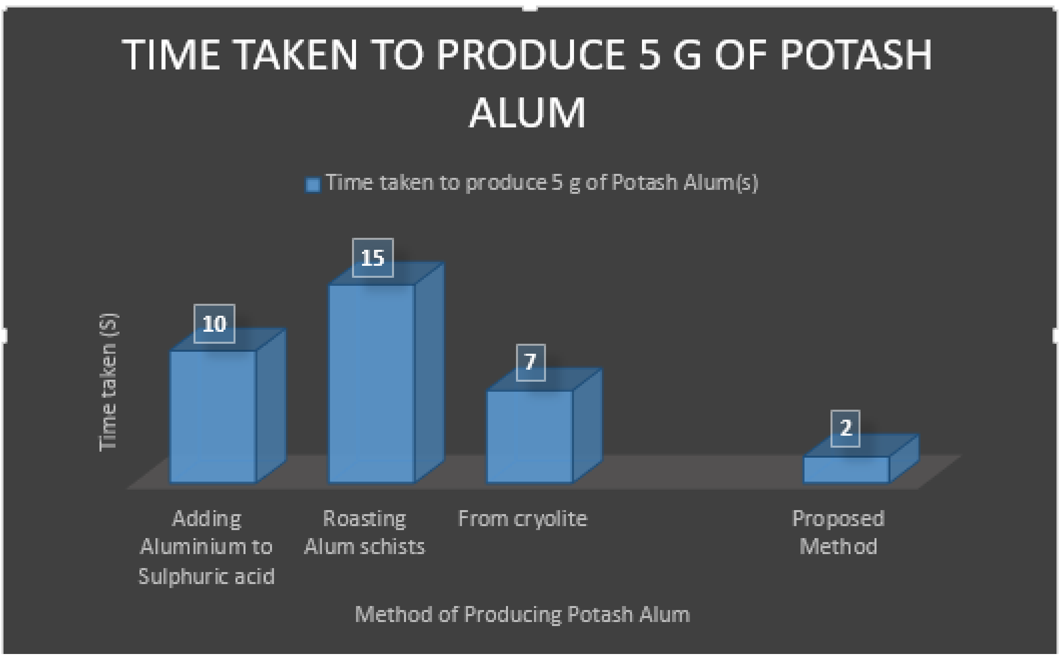


Fig 4.2: Quantity of Alum produced during experimentation

From the data collected from the experiment, it was concluded that as the quantity of Aluminium used increases, The quantity of Alum produced also increases as shown in table 4.2 and Fig 4.2 above.

Method of Producing potash Alum	Time taken to produce 5 g of Potash Alum(s)
Adding Aluminium to Sulphuric acid	10
Roasting Alum schists	15
From cryolite	7
Proposed Method	2

Table 4.3: Time taken to produce 5g of Potash Alum during experimentation



From the data collected from the experiment, it was concluded that the time taken to produce Potash Alum depends on the method of producing it. It is observed that the proposed method takes the least time in producing potash Alum as shown in table 4.3 and Fig 4.3 above.

4.3 Data Discussion

From the data collected, it was concluded that scrap Aluminium is one of the leading metal waste in Kenya. The general observation is that we never truly recycle the entire mass, some are lost to reactions and abrasion i.e. filing to get that smooth shinny Aluminium look. In general, the cycle number is the independent variable as it determines the kind of mass we will get before and after recycling. The masses shift as per the cycle number making them the dependent variables. However, the lost mass is insignificant and does not negate the entire process' value. From the data collected from the experiment, it was concluded that as the quantity of Aluminium used increases, the quantity of Alum produced also increases. From the data collected from the experiment, it was concluded that the time taken to produce Potash Alum depends on the method of producing it. It is observed that the proposed method takes the least time in producing potash Alum.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

From the data collected, it was concluded that scrap Aluminium is one of the leading metal waste in Kenya. The general observation is that we never truly recycle the entire mass, some are lost to reactions and abrasion i.e. filing to get that smooth shinny Aluminium look. In general, the cycle number is the independent variable as it determines the kind of mass we will get before and after recycling. The masses shift as per the cycle number making them the dependent variables. However, the lost mass is insignificant and does not negate the entire process' value.

From the data collected from the experiment, it was concluded that as the quantity of Aluminium used increases, the quantity of Alum produced also increases. From the data collected from the experiment, it was concluded that the time taken to produce Potash Alum depends on the method of producing it. It is observed that the proposed method takes the least time in producing potash Alum. This project comes at a time when availability of clean water is a challenge. Alum is a product used for water purification. With this innovation, "Alum from scrap Aluminium cans" the stated aims and objectives have been proved hence proving the hypothesis.

5.2 Future Research Adjustments

In future, the innovation will involve other Aluminium waste products different from cans. The researchers look forward to developing a machine that will easily remove the paints on the cans and cut the sheets into smaller pieces which will be easily reacted.

5.3 Recommendation

The researchers recommend this project for further research and improvement, so that there is no waste from the project. All the products produced like hydrogen can be harnessed and used.

5.4 Linkage to emerging issues:

Pollution and unemployment are perhaps the top of the list in Kenya's emerging issues among food shortage and others. By recycling Aluminium and its adoption we create jobs which helps Kenya improve its gross domestic product (GDP). In doing so we will also curb rural to urban migration since Aluminium can be found almost everywhere and industries can be delocalized. This eventually improves the general aesthetics of the land.

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APPENDICES

APPENDIX I: LETTER TO THE RESPONDENT

Dear Respondent,

I am currently a teacher at St Angela Sengera Girls' High School, Kenya. My Science club students are currently carrying out a research study on a project whose topic is:

"POTASH ALUM FROM ALUMINIUM SCRAP METAL CANS".

I therefore request for your information and cooperation in this exercise. All information will be treated with confidentiality.

Yours with regard

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