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Advances in Pulp and Paper Technology and the Implication for the Paper Industry in Nigeria

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Abstract
The technology of pulp and paper production has advanced considerably since the discovery of paper in AD 105. The improvements in technology have also increased the environmental impact of the processes through air and water pollution. Efforts are being made to reduce the enviromental impact of the processes through development of substitute raw materials. The increasing pulping of non wood raw materials, development of organosolv pulping methods, total chlorine free bleaching and introduction of nanotechnology in pulp and paper production aim at addressing these problems. The impact of the recent technological developments on the obsolete pulp and paper production facilities in Nigeria dictate that new investments are required in the sector if the country is to remove itself from being a perpetual paper importer.
Keywords: organosolv, nanotechnology, chlorine, kraft pulping, effluent

1.0 Introduction
Despite the development of information and communication technology, paper production still remain one of the industrial activities regarded as a pointer to industrialization and educational development worldwide, and, without doubt, pulp and paper production capacity is increasing. It is one of the high demand sectors in the world of industrial production (Sridach, 2009). In the light this, and, in view of the increasing protectionism of the environment, research and development in the sector have concentrated on overcoming environmental problems associated with pulp and paper manufacturing activities globally. For instance pulp and paper production is regarded as the fourth highest consumer of energy globally (Casey, 1980; Bublitz, 1980; El 1988; Gielem and Tam, 2006). It is also a major cause of deforestation, effluent discharge, air and water pollution (Anslem et al, 2012).

Consequently, research and development efforts have concentrated on reducing the environmental problems of pulp and paper poduction using various approaches which includes but not limited to adoption of substitute raw materials, pulping chemicals and variations in pulping time, temperature, pressure, and reduction in energy consumption, etc. These have continually led to restructuring of the pulp and paper sector, making it a business of continous change where wealth is no longer being measured by ownership of rapidly obsolescing fixed physical asset, but interms of knowledge, high- value added technology intensive propriety system. This is very imperative as the paper industry must be operated more efficiently and show more descipline around capital deployment. This paper review some of the technological advances made in the pulp and paper production process in order to address the afforementioned problems. The implication of the recent advances in pulp and paper technology to the near obsolete pulp and paper production facilities available in Nigeria coupled with near total dependence on pulp and paper importation in the country are also examined.

2.0 Historical Development of the Pulp and Paper Industry
Paper was invented in China by Ts'ai Lun in AD 105 (Wikipedia, 2014). Ts'ai Lun broke the bark of a mulberry tree into fibres and grounded them into a sheet. Later it was discovered that the quality of the paper could be much improved with the addition of rags. According to Palmer and Greenhalgh (1987), archeological evidence indicated that paper had been used in China at least for two centuries before that date. The first fibrous materials used were fishing nets and rags which were boiled and beaten to separate the fibres by use of a pestle and mortar or a wooden mallet on a slab of stone. To form the sheet of paper, moulds consisting of reeds sewn together with silk or horse hair and held in a wooden frame were used (Palmer and Greenhalgh, 1987) . The fibres were suspended in a large volume of water and either the mould was dropped into the vat containing the suspension of fibres or the suspension poured over the mould. This process formed the basis of paper production today. The paper was widely used in China and spread to the rest of the world through the Silk Road.

Paper production technology reached Europe in the 12th century and the USA in the late 17th century. However, in the East, paper making moved to Korea where production of paper began as early as 6th Century AD (Wikipedia, 2014; Herbert, 2006). In Europe, increasing literacy and population levels, together with industrial revolution in the second half of the 18th century led to a great increase in demand for paper. By this time, a large number of mills had been established in England and Wales. However, they were unable to meet demand as the output of individual mills was low and the process slow. Also, the rag raw materials supply was insufficient.

These conditions provided incentives for mechanizing the papermaking process and for expanding the raw materials base to include wood biomass (Sjostrom, 1993). The increased demand for paper also created the need for greater efficiency in production. In the late 18th century, workers of Nicholas Luis Robert fabricated a machine that produced seamless length of paper on an endless wire with squeezed rollers at one end (Sjostrom, 1993). Perfected and marketed by Fourdrinier brothers, the new machine made papers soon replaced traditional single sheets made by hand. The first Fourdrinier machine was very small. It was 1.3m wide, 8.3m long and produced 272 kg of paper in 24 hrs. This machine was the ancestor of the modern Fourdrinier machines which may be 10m wide with design speeds of 600-1500m per minute (according to the grade of paper being made) and capable of producing 1000 tons of kraft paper in 24 hours. The cylinder or the vat machine has developed mainly into a multi-vat machine used in the manufacture of boards. Consequently, in Europe and America, the mass production of paper became a thriving industry, supplying huge volumes of paper for production of newspaper, books, magazines, paper bags, toilet paper, money and a huge variety of paper for other purposes.

Experiments to isolate fibres from straws and grasses met with some success by the mid of 18th century. However, most of the pulp produced were unsatisfactory because of undisintergrated fibre bundles and very poor colour. Experimental work continued and was extended to include wood. In 1852, a mill for the commercial manufacture of mechanical wood pulp was established, and, in 1863, the one for the manufacture of soda chemical wood pulp started operation. Improvement in pulping technology has been continuous and included innovations such as kraft process which led to higher strength pulp and the ability to use a wider range of wood species, the successful use of chlorine and other chemical agents to produce pulp of high brightness and permanence, the recovery of chemicals used in pulping and the reduction of mill effluent were products of the research and development that took place in the 1860's to 1900. Since then, the art of papermaking became well developed and further research up till today has led to production of different type of papers and a variety of pulping processes.

3.0 Major Developments In Pulp and Paper Technology

According to Ragauskas (2014), the major global developments that have taken place since the discovery of paper are as follows:

- The first continous web paper machine was discovered in 1798
- The first deinking method was patented in 1801.
- The first commercial paper machine, the Fourdrinier machine debuted in 1807
- First drying cylinder was patented in 1820
- First kraft pulping process also debuted in 1865.

Between 1900 and 1950 a lot of developments took place in the industry. Notable among these are the integraton of kraft pulping and the bleaching process, introduction of chemical recovery system, and commercialization of digesters and secondary headboxes. Likewise, from 1950 to 2000, + wire width paper machines , composite felts, new wet end chemistries, hybrid deformers, high yielding pulping, Z, D, P. were discovered and commercialised, although, the improvements remains continous.

4.0 Advances in Pulping Processes for Softwoods and Hardwoods

Since the discovery of paper, the major industrial raw material has been lignocellulosic substances. These consists of hardwoods, softwoods, agricultural resisdues, and increasing number of non timber forest products (Ogunwusi, 2014; Rowel 1983; Rydholm, 1965). Basically, pulping has remained the liberation of individual fibres so that they can be suspended in water and be formed into sheet materials (Palmer and Greenhalgh, 1991). Apart from recycled pulp, three major class of pulping processes are adopted globally. These are the chemical, semi chamical and mechanical pulping processes (Ogunwusi, 2014, Palmer and Greenhalgh, 1991, McGovern, 1980; Osung and Apakpa, 2012). The use of wood began with mechanical pulping in Germany in 1840's. Chemical process quickly followed, first with the use of sulfurous acid followed by calcium bisulphite to pulp wood in 1867 (Biermann, 1993). Almost a decade later, first commercial sulfite mill was built in Sweeden. By 1900, sulfite pulping method had become the dominant method of pulping with soda process as a major competitor (Bryce, 1980) The sulfate or kraft process was the offspring of the soda process. It was discovered by Dahl, a German chemist in 1879. The invention of the recovery boiler in 1930's (Sjostrom, 1993) allow kraft mills to recycle almost all the pulping chemicals. Among other advantages of the kraft process are its high pulping rates, pulp yied, pulp quality and low production cost (Biermann, 1993; Herbert, 2006; Bryce, 1980). According to McGovern (1980), the process has several advantages over the soda process. Among these are its ability to pulp any wood species, thus allowing flexibility in wood supply. It also allow substantial amount of bark in wood chips and has short cooking time, excellent pulp strength properties, maximum recoverability of the spent liquor and production of by- products such as turpentine and tall oil from some wood species (Bryce, 1980). The chemical recovery and black liquor combustion make the highly capital intensive process economically feasible and provide a significant portion of the mills energy needs (Bryce, 1980).

In the semi –chemical pulping process, chemicals are used to soften the lignin and the fibres are separated mechanically. In the mechanical pulping process, the logs of wood are grind against a grindstone or chips ground in a disc refiner. Usually the pulp is composed of small lumps of fibres rather than completely separated fibres. This in addition to the presence of high quantity of lignin make the paper of limited application in colour separation technology (Ogunwusi, 2014; IPAB, 2008). The pulp yield of the three varieties of pulping processes vary from 45-70% in the chemical process to 55 to 85% in semi-chemical pulps and 85 to 90% in mechanical pulp mills (Palmer and Greenhalgh, 1991).

The major development that advance the use of hardwood fibres is the incorporation of the bleaching process into pulp and paper mills. While for a long time it was considered appropriate to pulp only long fibre from temperate softwood species with fibre length of 2 to 4mm for all types of paper, the situation changed drastically in the last decade (Rydholm, 1965; FAO, 1991). In the manufacture of printing and writing papers, good sheet formation is of good importance (Rydholm, 1965; Dinwoodie, 1965). Long fibres tends to fioculate and in order to overcome bad formation, the fibre length are reduced through beating, a process which influences important properties paper such as bulk, opacity and tearing strength (Dinwoodie, 1965). The introduction of short fibres from hardwoods lead to good paper formation and only a low degree of beating is required to obtain optimal sheet strength (Bryce, 1980). Short fibres also contribute to smoother paper surface and high opacity (Bryce, 1980; Dinwoodie, 1965).

5.0 Chlorine Free Bleaching

The pulp and paper industry is considered as one of the most polluting industries globally due to the huge qualities of waste water generated (Dence and Reeve 1996). Waste water from the pulp bleaching end is responsible for most of the colour, organic matter and toxicity of water dicharges of the industry (Kumar *et al.* 2012). The pulp produce by chemical pocess requires bleaching to produce bright pulps. The operation generates high environmental load and poses serious threat to the environment (Sighn and Thankor 2004). The need to reduce the environmental impact of bleaching has led to development of other bleaching methods. Modified bleaching techniques have made possible the development of elemental chlorine free (ECF) and totally chlorine free (TCF) processes that have alleviated the problem of the environmental impacts of bleaching effluent. The concept of total chlorine free pulp mill has increased in importance and seems to be the solution to the environmental problems related to pulp bleaching (Young and Akhtar, 1998). This is important as chroline bleaching creates a by-product called dioxin which has extremely harrmful effect on the environment. Dioxin is a known carcinogen and will leave detectable reactants in any product that has been bleached with chlorine. TCF is the only 100% chlorine free bleaching process which uses oxygen from hydrogen perioxide, and, today, elemental chlorine (CI) is no longer used in most mills (Young and Akhtar, 1998; Ogunwusi, 2014).

6.0 Organosolv Pulping

Organsolv pulping method was developed to avoid environmental problems related to sulfur emissions. Pulp production by organosolv process has been evaluated with several wood species and a broad range of organic solvents in acid and alkaline media. The method breaks up lignocellulosic biomass to obtain cellulosic fibers for pulp and paper making. Organosolv pulping method was developed to eliminate hemicellulose and lignin degradation products from generated black liquor, thus, avoiding emission and effluent (Azziz and Sarkanen, 1989, Herget, 1998; Pasnez, 1998). The process either use low boiling solvents such as methanol, ethanol and acetone which could easily be recovered by distillation or high boiling solvents such as ethyleneglycol and ethanolamine which can be used at low pressure and in available facilities in classical pulping processes (Sridach, 2010). Organosolv pulping process produce high yield pulp, low residual lignin content, high brightness and good strength (Yawalata and Pasnez, 2004). In recent years, research into organosolv pulping process has resulted in development of pulping methods capable of producing pulp with properties reminiscent to kraft pulp (Sridach, 2010). Among the methods developed that use alcohols are Kleinert (Azziz and Sarkanen, 1989), Akell (Lonnberg *et al.,* 1980), MD Organocell (Stockburger, 1987), Organocell (Lonnberg *et al,* 1987), ASSAM (Black, 1991) and ASAE (Kirci *et al,*1994). Other processes based on other chemicals also worthy of special note are ether pulping (Young, 1989), phenol pulping (Aziz and Sarkanen 1989), Acetocell (Newman and Balser, 1993), Milox (Poppius-Levin *et al* , 1991), Formacell (Sacke *et al.,* 1995), and NAEM (Paszner and Cho, 1989).

Closely allied to organosolv pulping process is the organic acid process. In this, organic acids are used to delignify lignocellulosic materials to produce pulp for paper (Poppius *et al* 1991, Jimenez *et al* . 1998; Lam *et al*,2001). Typical organic acids used in the pulping operation can easily be recovered by distillation and reuse in the process (Muurinen, 2000).

Biopulping which is the fungi pretreament of wood chips designed as a solid state fermentation process for producing mechanical or chemical pulps has also been developed. The concept of biopulping is based on the ability of some white rot fungi to colourise and degrade selectively the lignin in wood, thereby, leaving the cellulose relatively intact (Young and Akhter ,1998). Biotechnology derived technologies have been implemented in pulp and paper production in recent years. Energy savings and strength improvements in refiner mechanical pulping have been successfully demonstrated by the use of white rot fungi in the pretreatment of wood chips (Young and Akhter 1998). Kraft cooking of *Phaneroachaete chrysosphorium* degraded aspen wood chips also show increases in pulp yield and in tensile, burst and fold properties related to the incubation time in the fungi pretreatment (Oriran *et al,* 1990). In addition to the influence of white rot fungi on chemical and mechanical pulp yields, a number of studies have also been reported on fungi-organosolv pulping method. A significant increase in the organosolv delignification rate was reported for cooks of 1 month decayed wood samples pretreated with *T. versicolor* at 180 ^{0}C (Ferraz *et al* . 1996a). A comparison of the delignification kinetics showed that the same amount of residual lignin (6-8% on wood basis) was achieved by cooking both the wood samples, the undecayed and the 1 month decayed by *T. vesicolor* for 60 to 20 minutes respectively. This indicated that energy savings could be expected from organosolv pulping samples previously biodelignified (Young and Akhter, 1998).

7.0 Pulping of Non -Wood Plant Species

The fiber properties of raw materials dictate the end use of the paper produced from them. Softwoods and hardwoods became the major raw materials in the pulp and paper industry in view of their avialablility and abiquity (Rowell, 1983; Young, 1986; Casey, 1980). While non-wood fibers were originally used for paper making in the 17th century, wood became the dominant source in Europe (Pande, 1998). In view of its seeming inexhaustibility of supply and versatility, most modern pulp and paper mills rely on wood (Smook, 1994).

Currently however, there is a growing interest in the use of non-wood plants such as annual plants and agricultural residues as raw materials for pulp and paper production (Sridach, 2010). Non wood raw materials account for 10% of the total pulp and paper produced worldwide (El-Sakhawy *et al*. 1996). This is mostly made up of 44% straw, 18% bagasse, 14% reeds, 13% bamboo and 11% others. The production of non wood pulp takes place mostly in countries with shortage of wood such as in China and India (Oinonen and Koskivirta, 1999). More recently, there have been serious advocacies for the use of non wood species by several authors. King (1977) and Patil *et al* (2011), have recommended that developing countries should re-strategize and promote paper production processes that uses local raw materials to ensure sustainability of the industry locally. The pulping of non wood fibres has been reported as an ethically sound way to produce pulp and paper, compared to clear cutting of rain or primeval forests. According to Sridach (2010), the benefits of non wood plants as fiber sources are their fast annual growth rate and the smaller amounts of lignin that binds the fibers together. Also, non wood pulp can be produced at low temperatures with lower chemical charges. Likewise, non wood pulping can make small size mills economically viable, giving the simplified process and their non polluting nature (Sridach 2010). Additionally, non food applications can give another income to famers (Rousu, *et al* 2002; Kissinger *et al*, 2007).

Non wood fibers are used for all types of papers. It has been used to produce writing, printing and packaging papers (Onilude and Ogunwusi, 2012). This reflects substantially in the increased use of non wood fibres from 12,000 tons in 2003 to 850,000 tons in 2006 (FAO, 2009; Lopez *et al,* 2009). In a number of economies efforts are being put in place to develop long fiber pulp from the bast fibers of kenaf (*Hibiscus canabinus*) (Ogunwusi, 1997). Among the advantages of non wood fiber pulping are the high annual yield per hectare. The average annual yield per hacter of kenaf, a non wood fiber, is about twice that of growing softwood (Pierce, 1991). Non woods are generally easy to delignify due to their lower activation energies. The major disadvantage of non wood fibers pulping is the unavailability all the year round. As annual plants, large storage capacities need to be developed to ensure constant supply. This, is in addition to the bulky nature of non wood fibers and high silica content. Also, non wood fiber require high inputs for growth, thereby contributing to climate change problems. Another major problem of non wood fiber pulping is the significant variation in their chemical and physical properties compared to wood fibers (Gumuuskaya and Usta, 2002, Chram *et al*, 2006). The properties vary, depending on species and the local conditions such as soil and climate (Bicho, et al 1999, Jacobs et al 1999). Short fiber length, high content of fines and low bulk density are the most important physical features of non wood raw material (Oinonen and Koskivirta, 1999; Paavlaiinen, 2000). Nevertheless, pulping studies on wood fibres indicated that pulp production from non wood resource has several advantages. These include ease of pulping, excellent fiber for the special type of papers and high quality bleached pulp (Sridach, 2010). They can also be used as an effective substitute for the over-exploited forest wood resources (El-Sakhawy *et al* . 1995; 1996; and Jimenez *et al.* 2007).

8.0 Nano Technology In Pulp and Paper Making

The benefits of nano technology are revolutionary in nature. Through application of this process, a leap in todays products as well as manufacturing fundermentals can be expected (ERSCP, 2004). Advances in the field of micro and nano technology can bring high benefit to the pulp and paper producers as well as help the industry reach its goals for the future. Celloluse and ligno cellulose have great potential as nano materials as they are abundanly renewable, have a non fibriller structure and can be made mutifunctional and sellf assemble into well defined architectures (Mohieldin *et al.* 2011). While many mills are just introducing micro and nano technology into their production processes, a wide range of paper and packaging industries have already incorporated nanotechnology througout their production systems (Norris, 2011). As the basic concept of all types of fibers in paper making is the cellulose or more precisely the glucopyranose unit measuring 5.25 nanometer, paper machine manufacturers have been including nanotechnolgy for years as a way to improve production quality (Patil 2011). The use of micro sensor for on line measurement and the adoption of processes such as nano coating have become common for paper production, enabling mills to produce higher, more consistent quality. Norris (2011) observed that nanotechnology is employed substantially in the production of packaging materials for security, conterfeting, safety and microbial uses. It has also been introduced in antibacterial paper, tissue paper and newsprint (Norris, 2011). Many companies are aready introducing nanotechnology into existing fcilities, most especilally, in the areas of plantation development, wet end, calendering, and coating of paper and packaging materials. The bottom line of introducing nanotechnology in the paper making process is to produce paper without any pollution at least cost. Advancements in micro particle and micro-polymer technologies are been deployed to improve retention and drainage at the wet end (Patil, 2011). More recent findings showed promising results in application of nanotechnology in electrospining, chemical treatment followed by mechanical techniques or mechanical isolation applied by different research groups to prepare cellulose nano fibers (Mohereldin *et al.* 2011). Expectedly, nanotechnology will continue to play a major role in the development of new products, substitution of existing chemicals and materials with cheaper ones based on improved performance and potential cost savings (ERSCP, 2004). New materials can be made of cheaper and more renewable resources. This provides paper machine with a wider flexibility in construction material selection in the future (Procter, 2002)

9.0 Substitution of Wood with Recycled Paper

The problems relating to climate change, long gestation period of wood species, diminishing natural forests and problems relating to monocultural plantation establishment necessitated the need for efforts to be made to utilize present supplies of wood as efficiently as possible and to employ other sources of fibre in the paper making production process (Oguwusi, 2014; Arjowiggins, 2009) A major way this is being handled globally is increasing utilization of post consume recycled paper. Although, for many years, secondary fibre pulping does not keep pace with the overall growth of the paper industry, recent economic factors and environmental considerations have caused it to expand greatly (Felton, 1981). Nowadays, secondary fibre has become the second largest source of fibre for paper and paperboard globally and its use is expanding. Among advantages of utilising recycled paper in the pulp and paper production processes are lower consumption of water, energy, virgin fibre and lower greeen house gas (GHG) emission. Table 1 compare the environmental impact of papers produced with various percentages of recycled fibres with that of virgin wood. From the table it can be observed that papers produced from 100% recycled papers consumed approximately 53% water, 20% energy and released 55% GHG emission, compared with those produced from 100% virgin fibre, and a combination of 60% recycled fibre and virgin pulp (Table 1). Also, paper recycling helps cut down on waste paper that would otherwise be sent to landfills or incinerators. Papers used for landfills currently accounts for 25% of methane gas released from landfills. Also, municipal landfills accounts for one third of human related methane emissions of 1.6 million tons of GHG. In Europe over half of the raw material used for paper making is recycled fibre. The use of recycled fibre increased from 62% in 2005 to 64.5% in 2007 in Europe. In Chile, only 1.2% of total wood consumed end up as waste and in New Zealand, the industry has achieved 78% recovery rate of paperboard packaging, exceeding the global target of 70% (ICFPA, 2009). In most cases, writing and printing papers used only 6.5% recycled paper while tissue papers used 45% in their production processes. In Nigeria, 100% recycled papers have been used to produce kraft paper for the packaging industry by the Nigeria Paper Mill, Jebba (RMRDC, 2010). However, as demand for recycled paper globally will exceed supply by 1.5 million tons per year within the next 10 years (ICFPA, 2009), it is imperative that other sustainable sources of fibre be determined for industrial pulp and paper production.

10.0 Reduction in Water Utilisation and Effluent Discharge

While not on the frontline, recycling of waste materials such as waste water and waste energy is a locally desirable means of reducing greenhouse gases. More recently, the paper industry has been reducing the process water consumption per unit of production. According to Springer and Peterson (1981), industry wide data suggest a decrease from 163m^3/tons in 1955 to approximately 113m^3/tons in 1972. For non integrated fine paper manufacturers in 1970, the average process water was 151m^3/tons and by 1972, this was reduced to 100m^3/tons. More recently however, in view of the threatening effects of climate change, there is need for formation of industrial symbiosis with respect to water recycling. While geographic concentrations of industry are often heavy generators of green house gases, impacts of the effects on GHG can be modulated through collaboration approaches. Emerging industrial ecology dictates that where a cluster of geographically proximate companies exchange material by-products such as water and energy in mutually beneficial manner, waste products from one industrial process can become feedstock for another (Chertow, 2009).

11.0 Implications of the Developments For Sustainable Pulp and Paper Production In Nigeria

Primary pulp and paper production in Nigeria is currently at the doldrums as the integrated mills are currently out of production. Out of three primary pulp and paper mills, only the Nigeria Paper Mill is producing packaging papers from 100% recycled fibre. Before the mills were pravitized between 2005-2007, they have been extensively canibalised with negative networth (TCPC, 1993). While efforts are on to refurbish the mills, it is important that the new owners take into consideration the need to source their primary raw materials, mostly pulping chemicals and long fire pulp locally (Ogunwusi, 2014; Picornel, 1991; Patil, 2011). If the country is to go by the initial pre privatization plan, heavy dependence on imported inputs it will require more than 150 billion naira annually for the importation of long fiber pulp and chemical at full production capacity (Onwualu, 2010; RMRDC, 2009; Ogunwusi, 2014). Thus, it is imperative for the new owners to carry out studies that will determine the feasibility and profitability of using organsolv pulping methods at the mills and to examine the possibility of pulping non wood cellulosic fibers such as kenaf . According to Ogunwusi and Onwualu (2013), the cost of non functioning of the mills to the Nigerian economy is more than 100 billion naira annually. It is also important to stress that paper requirement in the country has increased tremendously. If all the integrated mills are to function of full capacity, they can only supply about a third of paper requirement locally (RMRDC, 2003; 2009). As a result of this, it has become mandatory for government to promote investment in small scale pulp and paper mills as done by India in the 1970's to 1990's. Small scale paper mills that depends of kraft process are highly polluting as the chemical recovery aspect has not been perfected (UNIDO, 1979). Thus, organsolv pulping method may be used in view of its environment friendliness. Nigeria should be part of development in nano paper or nanotechnology. Currently, facilities for pulp and paper research and development in the country are obsolete where they exist. These need to be overhauled and adequate research in the tropical hardwood pulpwood utilization including the use of available non timber tree species be assidously embarked on. If the situation in the industry is left as it is, Nigeria may become perpetual importer of paper.

12.0 Conclusion

The development of information and communication technolgy has not critically reduce the dependence on pulp and paper, most especially, writing and duplicating paper. The area where the effect is felt to any reasonable extent is in the demand for newsprint as a number of people now read online. However, the capital intensity of investment in pulp and paper production and the associated maginal profit are making it difficult for new investment to be enbarked on even in developed countries. To combat, this pulp and paper experts have developed pathways aimed at reducing investment cost and increase profit in the industry. Most of the inovations developed are being put into practice comercially. While these are taking place in developed economies, the situation is subsahara African countries remains pathetic. If adequate care is not taken, most of the countries in these area, most especially, Nigeria may be perpetual importer of paper despite the recent developments.

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Table 1: Comparison of the Environmental Impact of Papers made of various % of Recycled Paper and Virgin Pulp

S/N	Consumption/Emission for/Ton of Paper	Non Recycled Paper	Paper with 60% Recycled Fibres (MS Green Range)	Papers with 100% Recycled Fibres (Cyclus Ranged)
		100%	40%	0%
1.	Water consumed	100%	65%	53%
2.	Energy consumed	100%	80%	20%
3.	GHG emissions	100%	80%	55%

Source: Arjowiggins (2009)