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Utilization of by-products and Cleaner Production in industrial Nile perch processing in Kenya

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ABSTRACT

Purpose: The Lake Victorian Nile Perch (*Lates niloticus*) industry in Kenya is the most important in the fisheries sub-sector and generates significant levels of revenue to the national economy besides creating employment opportunities along the value chain. Information on the utilization of by-products and cleaner production is very important as the industry plays a significant role in the economic and social development in the country. The main products from processing are chilled or frozen Nile perch (NP) fillets exclusively destined for the export market. The processing further produces vast amounts of waste water.

Methodology: NP by-products and CP were audited by surveying three NP processing plants in Nairobi, Homa Bay and Kisumu. The three fish processing plants were purposively selected. Simple random sampling technique was used to select respondents as it presented every potential respondent an equal chance of being selected to take part in the study without bias. A sample of 139 was used. Structured questionnaire, structured interview schedules and observation checklists were used as research instruments. Data was analyzed using Statistical Package for Social Sciences (SPSS).

Results: There has been an increasing interest in Nile perch by-products over the past two decades. Various factors were tested to have negative significant association with utilization of by products that included lack of expertise with a correlation of -0.716, lack of appropriate technologies with -0.874, financial constraints with -0.624, lack of markets, -0.559, lack of raw materials with -0.547 and poor management practices with -0.738 correlation coefficient. The results of this study indicated that there were several by-products and these included fish maws, fish frames, skins, scales, viscera, fish pads and proteinous thick liquid. Cleaner Production (CP) employed by the Nile Perch processing plants was to a large extent covered by the fisheries regulations, company policies, Hazard Analysis Critical Control Point (HACCP), Sanitation Standard Operating Procedures (SSOP) and Good Manufacturing Practices (GMP) which were documented in various manuals.

Recommendation: The government in consultation with the industry should develop and implement appropriate policies that govern the utilization of the by-products. There is need to build capacity on the part of the management and the employees on the principles and implementation of CP. Through this, the NP management needs to fully align CP with the documented HACCP and SSOP manuals that are currently in place in all the NP processing plants. There is a need to find appropriate ways of reducing water and energy usage as well as minimize the amount of waste released into the environment in order to avoid the negative consequences.

Keywords: *Nile perch, processing, utilization, by-products, cleaner production.*

1.0 INTRODUCTION

The importance of fish as a crucial element in diets, especially the diets of infants, young children and pregnant women, is now widely recognized and today more people are turning to fish as a healthy alternative to red meat (Tidwell & Geoff, 2001). Fish is an important source of protein and its harvest, handling, processing and distribution provides livelihood for millions of people as well as providing valuable foreign exchange earnings to many countries (Abolagba & Chukwu, 2008).

In 1999, FAO (Food and Agriculture Organization of the United Nations) estimated that 47% of the world's fish stocks were fully exploited and 18% over-fished (OECD, 2003). World capture production in 2002 was about 93 million tons and has been stable for the past six years (FAO, 2002). At the same time the world's population has had an approximate annual average growth rate of 1.2%. With no increase in fish capture and an increase in population, food security from marine resources is likely to be compromised in the future. According to FAO less than 100 million tons of fish are harvested each year and large amount of this valuable commodity is wasted (FAO, 1995; Kurien, 2004). FAO estimate that post-harvest loses remain at approximately 25% of the total catch (Kelleher, 2004). Approximately 30% of the total catch is used for fish meal and animal feed because of its unattractive colour, flavour, texture, small size, high fat content or poor functional properties (Rebeca *et al*., 1991; Venugopal & Shahidi, 1998) and a relatively small part of the total catch is used for human consumption.

In 2009 the fisheries sub-sector in Kenya supported about a million people directly and indirectly, working as fish traders, fish processors, merchants of fishing accessories and their dependants (Ministry of Fisheries Development, 2009). Commercial fish catch in East Africa is dominated by Lake Victorian Nile Perch, (*Lates niloticus*). In 2012, Kenya produced 154,015 metric tons of fish from inland, aquaculture and marine artisanal fisheries with an ex-vessel and farm gate value of USD 210 million and this accounted for 0.5% of the country's Gross Domestic Product (GDP) (Ministry of Agriculture, Livestock and Fisheries, 2012). The Nile Perch (NP) is processed into chilled and frozen fish fillets mainly for export. The European Union (EU) market where Kenyan fish is mainly exported offer premium price for fish and fishery products but exporting countries must meet stringent food safety requirements in the primary production areas, transportation and during processing (Abila, 2003). In November

1997, the EU imposed a ban on Kenyan fish exports over claims on the presence of Salmonella in fish.

Cleaner Production (CP) is the continuous application of an integrated preventive environmental strategy applied to processes, products and services to increase overall efficiency and reduce risks to humans and the environment (UNEP, 2004). For production processes, CP involves the conservation of raw materials and energy, the elimination of toxic raw materials and the reduction in the quantities and toxicity of waste and emissions. World over, the utilization of by-products is an important opportunity for the industry since it reduces environmental burdens and can potentially generate additional revenue. By applying preventive environmental strategies in a systematic way through CP, companies have been able to reduce inefficiencies in the processing and reduce the amount of wastes generated. More efficiency translates to less costs and increased profits, thus benefiting the company both in financial terms and in improved environmental performance.

According to a study carried out by in Iceland, some of the main present and future challenges for fish processing industry were to increase productivity and reduce production costs (Stefan, 2003). In the future, more pressure will be on companies to improve their environmental performance, in particular regarding wastewater effluents due to increased treatment costs. The demands regarding the environmental performance of manufacturers can be expected to increase. The challenge is how to address environmental concerns without compromising progress in other areas within the fishing industry. In Kenya, NP constitutes 60% of the total commercial fish catch and is mainly processed into chilled and frozen fish fillet for export (Mbatia, 2011 and Breivik *et al*., 1997). Fresh fish products are highly perishable and refrigerated storage is required throughout the life of the product to maintain eating appeal and prevent microbiological spoilage. The processing leads to high volume of by-products. The by-products include fish maws, fish frames, trimmings and roe/eggs, fat-pads, skins, scales and viscera. The annual solid waste generated by fish processing industries along Lake Victoria (Gumisiriza *et al.*, 2009) is estimated at 36,000 metric tons.

A further increase in the generation of fish processing wastes in Kenya is expected with the identification of aquaculture development as a means to increase fish production in the country and as a tool to eradicate poverty and hunger in the region. The waste generated can be processed into by-products and sold to earn the industry money and reduce environmental pollution through discharge of effluents and dumping of wastes into the environment. Disposing and managing the waste is a challenge facing many fish processing plants in the region and in particular Kenya.

This paper presents the results of a study conducted to find out the utilization of by-products and CP in the industrial NP processing in Kenya and proposes alternative options to redress the situation

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2.0 MATERIALS AND METHODS

Utilization of by-products and cleaner production

NP by-products and CP were audited by surveying three NP processing plants in Nairobi, Homa Bay and Kisumu. Information regarding the nature and type of processing, quantity and quality of waste generated and the current Cleaner Production were collected through a guided survey along the processing lines of the three NP plants, filing questionnaires and conducting open ended interviews.

Sampling

The three fish processing plants were purposively selected. Simple random sampling technique was used to select respondents as it presented every potential respondent an equal chance of being selected to take part in the study without bias.

The Fisher's formula Mugenda and Mugenda (1999) was applied in determination of the sample size in this study.

$n=Z^2pq/d^2$

Where, n= desired sample size

Z= standard normal deviation set at 1.96 (95% confidence level)

P= proportion of the targeted population that have the characteristic focusing in the study estimated at 90%.

q=1-p

d= degree of accuracy set at 5% / degree proportion of error that should be accepted in the study (0.05) since the study is at 95% confidence level.

Thus Desired Sample (n) **=** **{**1.96^2*(0.90*(1-0.10)}/0.05^2

n= 139

Three instruments used in this study include structured questionnaire, structured interview schedules and observation checklists.

Since the total population for each region is less than 10,000 the researcher applied finite correction formulae (nf) that is applied together with the Fishers formulae in successive steps as indicated:

$$nf = \frac{n}{1+ n/N}$$

Nairobi: N = 210, n = 139

nf= 139/(1+139/210) = 84

Kisumu: N= 280, n= 139

nf= 139/(1+139/280) = 93

Homabay: N= 170, n= 139

nf= 139/(1+139/170) = 77

Total Sample Size = 254

Data analysis

After data collection, the so collected data was coded and entered in the data analysis tool for ease of analysis. Data was analyzed using Statistical Package for Social Sciences (SPSS) and Excel computer package and results were presented using bar graphs. The use of SPSS eased summarizing of the data in descriptive statistics of frequencies and percentages that shows the trends in the collected data. The software was also used to conduct inferential tests in the data collected. Inferential statistics used included correlation, ANOVA and chi-square statistical tests. The tests were conducted at 5% level of significance with a critical value of 0.05. The software was also used to generate figures showing the results. After generation of categories, themes and patterns an analytical and interpretive report giving a descriptive account of the factors affecting the utilization of NP by-products was written. Each of the three hypotheses was tested independently by use of statistical chi-square and the results presented in a table.

3.0 RESULTS

Surveys

Surveying revealed that generally most of the NP processing plants along Lake Victoria are in the major urban centres located at the lake periphery due to good transport network that link them to market centres both locally and internationally. The exception was Nairobi; the commercial hub in East and Central Africa.

Age of respondents

The study results showed variations in the age and gender of the respondents in the NP processing plants. In all the three processing plants, majority of the respondents were in the age group 31-40 years; being 43%, 48% and 42% in Nairobi, Kisumu and Homa Bay respectively while the age group below 20 years and between 51-60 years were the least (Table 1).

Table 1: Respondents age groups in percentage

Age group in years	Nairobi %	Kisumu %	Homa Bay %
<20	5	8	7
21-30	25	32	23
31-40	43	48	42
41-50	24	7	23
51-60	3	5	5

By-products generated from NP processing

The study revealed that the main products generated are fresh, chilled and frozen NP fillets, frozen Headless &Gutted NP. The study also found out that there are several by-products from NP processing which include fish maws (swim bladder), fish frames (skeletons), belly flaps, fish roe/eggs, visceral fats, trimmings, "fish chest", head, skins and trimmings. Fish maws are processed through the removal of the fish bladder from the freshly dead fish. The fish bladders are washed in cold fresh water and carefully scraped to remove the adhering blood and fat.

The semi-processed fish maws are subjected to freezing and packed in waxed cartons for export mainly to the Far East where they are used as the raw material from which isinglass, used as refining agent in the manufacture of beers and wines, is produced. The local market price for the unprocessed fish maws was USD 14.1 in Kisumu, USD 11.7 in Kisumu and Homa Bay. The high price offered in the local market had firmly established the trade in the NP processing plants. Further, in the Far East, the fish maws are fried in cooking oil and are considered a delicacy. The fish frames, chests, trimmings, fat pads and fish roe/eggs are sold into the local market where they are further processed for human consumption. Most of the by-products are transported from the factory in open pick-ups without ice (Kabehenda 2009b). NP frames are usually used as food by the local community, to make animal feed and the excess is dumped (Kabehenda *et al*., 2009a; Gumisiriza *et al*., 2009). In Nairobi as indicated in Figure 1 below the price per kg for fish frames, trimmings, fish chests and roe was USD 0.26, 2.12, 1.2,0.49 and 0.59 respectively whereas in Kisumu fish frames sold at USD 0.18, trimmings USD 0.9, fish chests USD 0.7, and roe USD 0.35. In Homa Bay the price per kg was USD 0.15 for fish frames, trimmings USD 0.6, fish chests USD 0.5 and fish roe USD 0.59. In all the three plants the selling price for fish fats was USD 0.59.

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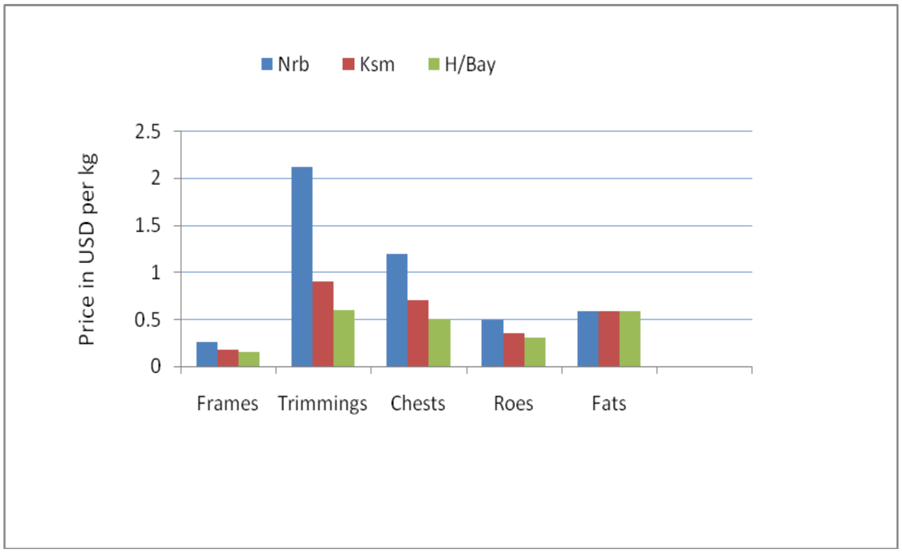

Figure 1: Average selling price of by-products in the three NP plants

Factors that affect the utilization of by-products

The study revealed that the utilization of by-products is hindered by several factors. The factors were similar in all the three NP processing plants but there were variations in the percentages in which it affects the utilization of the potential by-products (Figure 2). The NP plant in Nairobi 15% of the respondents attribute non-utilization of by-products to lack of expertise, 13% to lack of appropriate technology, 25% to financial limitations, 12% to lack of ready markets, 21% to lack of raw material, while the remaining 14% cited to poor management

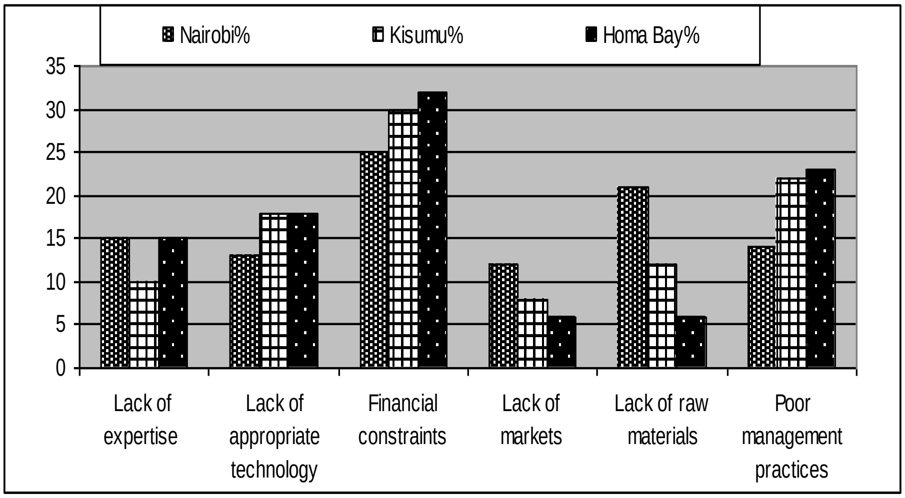

Figure 2: Factors affecting utilization of by-products

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Cleaner production in NP processing plants in Kenya

In all the three establishments all the respondents; 100% indicated that CP measures were in place. However there were variations in regard to the measures that contributed towards effective CP as shown in Figure 3. Amongst the reasons cited were the Fisheries regulation, Supervision, SSOP, Company Policy and GMP.

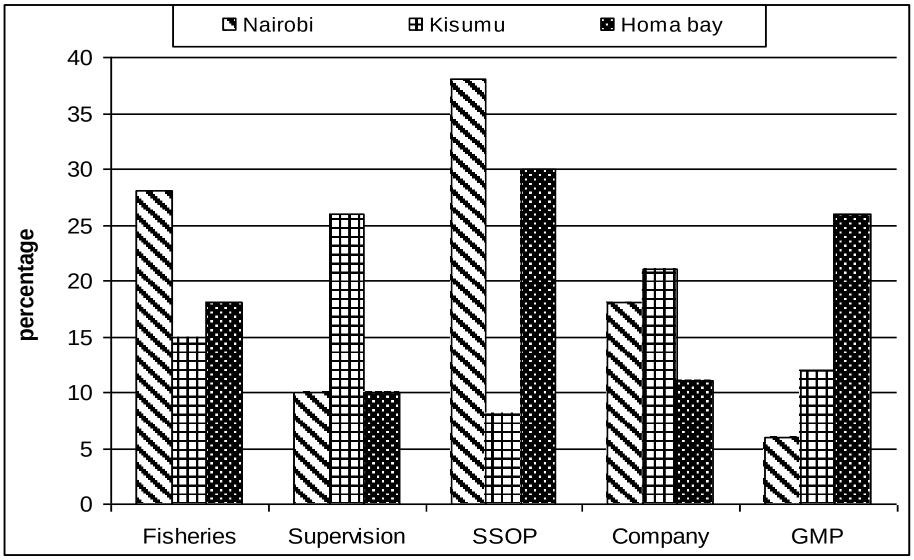

Figure 3: Internal regulation governing CP

It was further noted that all the three establishments had developed and implemented a HACCP system. The NP plants were regularly inspected by the Competent Authority (CA) which is Ministry responsible for fisheries and a comprehensive HACCP based audit was carried out by the CA once a year.

The study observed that CP improved with the utilization of by-products by reducing the amount of waste generated and disposed by the NP processing plants in Nairobi, Kisumu and Homa Bay. 75% of the respondents in Nairobi, 79% in Kisumu and 79% Homa Bay indicated that utilization of by-products reduced the amount of waste generated as findings in Figure 4 shows.

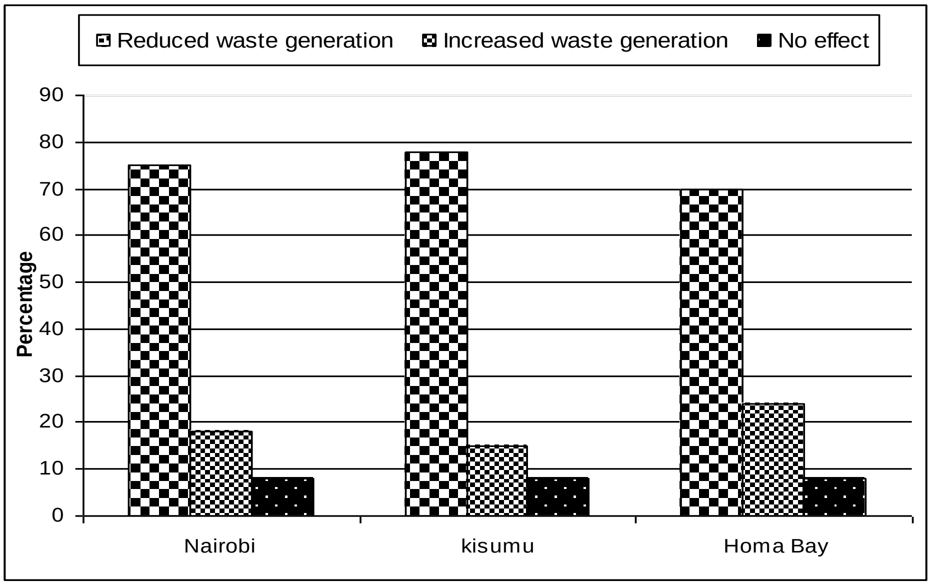

Figure 4: Effects of utilization of by-products on waste generation

Testing association between factors identified and by-product utilization

Testing the association between the factors identified and their influence on utilization of by-products, the Pearson correlation test was conducted at 5% level with a 2-tailed test. All the factors identified showed a negative association with utilization of by-products as shown in the Table 2 below. These were also found to have a statistically significant association as given by their p-values that are all less than 0.025 at 5% level. This therefore shows that there is statistically significant association between these factors and the extent of utilization of the by-products.

Table 2: Association between factors identified and by products utilization

		Utilization of by-products
Lack of expertise	Pearson Correlation	-.716*
	Sig. (2-tailed)	.010
Lack of appropriate technology	Pearson Correlation	-.874*
	Sig. (2-tailed)	.003
Financial constraints	Pearson Correlation	-.624*
	Sig. (2-tailed)	.009
Lack of markets	Pearson Correlation	-.559*
	Sig. (2-tailed)	.012
Lack of raw materials	Pearson Correlation	-.547*
	Sig. (2-tailed)	.021
Poor management practices	Pearson Correlation	-.738
	Sig. (2-tailed)	.017*

*. Correlation is significant at the 0.05 level (2-tailed).

4.0 DISCUSSION

Studies conducted amongst catfish processors within Ibadan Metropolis in South-Western Nigeria showed that where physical strength was involved 88.3% of the respondents were between 21 and 50 years old which coincided with the age for economic activity in humans (Akinpelu *et al*., 2013) meaning that most of the catfish processors were still in their productive age while 9.6% were between the ages of 51 and 60 years. This compares favourably with the findings in NP plants in Nairobi, Kisumu and Homa Bay. The disparity in age of male and female processors may be due to the household responsibility that is placed upon the female processors than their male counterparts at early stage of life especially as it concerns children upbringing. Other household responsibilities may be expected of the female gender, many of whom fend for the household with little or no assistance.

The study revealed that the utilization of by-products is hindered by several factors. The factors were similar in all the three NP processing plants but there were variations in the percentages in which it affects the utilization of the potential by-products. These were lack of expertise, of appropriate technology, financial limitations, lack of ready markets, lack of raw material and poor management. These factors were in line with a study conducted in India indicated that among factors that affect the utilization of by- products include water availability and allocation, ever-increasing input costs of water and power, high perishability of fish coupled with poor post-harvest handling, quality assurance in production, processing and exports, market fluctuations, disaster management, availability of bank credit and insurance, inadequate database and poor linkage in domestic marketing, lack of storage facilities and transportation (DFID, 2003).

The high prices in Nairobi for all the by-products except fish fats could be attributed to the high population in the city and great demand for low priced protein based products especially in the low income settlements and the transport costs incurred by the traders. In the case of fish fats, the uniform price in all the three could be due to the fact that NP is a fatty fish and the oil is not of immediate consumption to the users and requires further processing.

All the three NP plants had implemented a Hazard Analysis Critical Control Point (HACCP) system that identifies, evaluates and controls hazards that are significant for food safety. HACCP is internationally accepted for the production of safe food. The system requires a HACCP team approach and full commitment of management and employees. It is a dynamic system that can adjust to new knowledge and experience. The system is built onto GMP and GHP which are pre-requisite programs in the implementation of a HACCP food safety system. In relation to food safety, (HACCP) has become a widely use tool for managing food safety throughout the world. It is an approach based on preventing microbiological, chemical and physical hazards in food production processes by anticipating and preventing problems, rather than relying on inspection of the finished product. This system was quoted as contributing greatly to the CP even though was not documented amongst the NP plants mandatory procedures.

There are other studies that document different results on CP production practices. Cleaner production in fish plants in Iceland vary as Stefán (2003) cites, these include dilution, seen in practice as higher chimneys and longer effluent pipes, 'end-of-pipe' solutions where wastes are captured 'end of pipe', before they enter the environment which entails the treatment and disposal of the subsequent substance that has been captured.

4.1 CONCLUSION

All the three NP processing plants generated by-products that were un-utilized to derive maximum economic benefits. Based on the findings of this study, the utilization of by-products by NP processing plants faces a lot of challenges among NP plants in Kenya. Lack of expertise, lack of appropriate technologies and financial limitations were cited as the major factors contributing to poor utilization of by-products.

Much of the current marketing efforts have focused on expanding sales to existing buyers, rather than seeking out new markets and new products. These challenges need to be dealt with promptly since the utilization of these by-products would not only improve their profits but they can also create more jobs and contribute to economic development of the industry and the country.

Utilization of by-products and CP can help reduce the reported negative effects of improper waste disposal by the plants to the environment, human and animal lives. The results of this study show that the application of CP can significantly improve the competitiveness of NP industries and reduce the negative environmental impacts of existing production processes due to the efficient use of water, energy and raw materials. Overall CP contribute to quality improvement, new market opportunities, better work environment, better image and ease of compliance to regulatory requirements to the industry.

4.2 RECOMMENDATION

The government in consultation with the industry should develop and implement appropriate policies that govern the utilization of the by-products. Priority on low cost potential options for the utilization of potential by products should be given.

There is need to build capacity on the part of the management and the employees on the principles and implementation of CP. Through this, the NP management needs to fully align CP with the documented HACCP and SSOP manuals that are currently in place in all the NP processing plants.

There is a need to find appropriate ways of reducing water and energy usage as well as minimize the amount of waste released into the environment in order to avoid the negative consequences. The National Environmental Management Authority standards do not recognize wastewater reuse as a possibility. It is therefore necessary for Kenya to recognize wastewater as a resource and specify necessary requirement for it to be used in the industry. A national policy on wastewater processing and reuse is necessary to enable the country enhance water availability for a variety of uses. Appropriate measures and technologies need to be employed to improve cleaner production.

Taking into account that there is a notable decline in the production of lake Victoria NP stocks and that the future of Kenya fisheries lies in marine sub-sector it is recommended that future research be focused on by product utilization and CP in the tuna processing industry.

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