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Life Cycle Assessment and Management of Water Use in Selected Breweries in Nigeria

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Abstract Capacity to promote resource conservation and efficiency must be embraced in all nations of the world**.** Beverage industries are a major manufacturing business concern in Nigeria which is intrinsically water intensive. The modern brewery can produce a stable product even though raw materials, plant types and the scale of operation are changing. This paper assessed the water use in selected breweries in Oyo and Osun State by using Ibadan Plant of the Nigerian Bottling Company and Ilesha Standard Breweries as case study. The methodology employed for this research work was by collection of primary data using questionnaires, field study and analysing the data with a *Water Audit Tool* developed by UNEP. A combination of purposive and random sampling techniques was used to select those that is relevant to this research work. Part of the objective was to recommend holistic approach for treating and reducing the wastewater from each brewery in a manner that will reduce the volume and ensure effective disposal in an environmentally sustainable manner. Water consumption and specific use (hl water / hl beer) varies greatly between individual breweries in the study locations. The two breweries are still far from the accepted international best practice benchmark level of 6.5 hl water/hl beverage, let alone the best technology level of 4 hl/hl. Presently, Ibadan brewery is consuming 10.22 hl/hl while Ilesha brewery is consuming 8.75 hl/hl. It was concluded that the efficiency levels of the two breweries can at best be described as medium. The water use in Ilesha brewery is better than that of Ibadan brewery. The financial implication of water loss can be minimized if the management method is improved for maximum effectiveness and optimal benefit.

Keywords Water Use Assessment, Brewery Wastes, Life Cycle Management

1. Introduction

Water resources engineering is the profession that is responsible for the planning, development and management of water resources; including estimating the amount of water available to designing the physical and non-physical infrastructure needed to meet the water needs of society and the environment. Nigeria is endowed with abundant water resources although its distribution and availability for use varies widely, with quite a number of countries facing water shortage and water stress. Regional and national water figures often conceal the effects of local water scarcity, limited or polluted supplies and inadequate distribution systems. Access to fresh water has been identified repeatedly as a key condition for development.

The impact of water use on our ecosystems has become a global issue. There is increasing impact on water from wastes, air pollution, privatization, and the exacerbation of climate change. Harlander and Labuza (2006) drew global attention to the need to preserve and conserve water for future generations.

National water policies and conservation efforts often tend to focus on the supply-side for domestic and agricultural use, and less commonly on industrial needs. Under these circumstances the uncontrolled use of the limited resource by water intensive industries takes on a special significance. A prospective Life Cycle Assessment (LCA) was carried out to examine the potential environmental impacts of water use in two purposively selected breweries in Nigeria. The authors have good course to believe that this is the first study to create an LCA model of an integrated water and wastewater system using the Water Audit Tool by the United Nations Environment Program (UNEP) used in Auditing water use in breweries of African countries such as Ethiopia, Ghana, Morocco and Uganda (UNEP, 2006).

It is good to finally see life cycle assessments being done for water use. More freshwaters and groundwater used and wasted in industries are not accounted for. Even though these assessments are not based on changing factors over time, they at least give a good idea of what is being used, wasted, and how best to conserve water in different regions of the world experiencing different effects regarding usage due to population growth, deforestation, agriculture, and impact of climate change. Drought and melting glaciers contribute to global warming which absolutely affects the life cycle of water and all that depend on it (Osho and Dashell, 1997).

Brewing industry uses large amounts of water of which over 70 % ends up as trade effluent. Unit costs for water supply and trade effluent discharge are expected to continue to rise as water companies invest in the new water treatment plant needed based on water demand. Water and effluent costs are controllable. A water management programme can produce savings of over 20% through good housekeeping and low-cost measures. Improving Profitability through Waste Minimization can be achieved in brewery. Water and effluent costs are controllable. Projects with a payback period of less than two years will allow you to achieve savings of at least a further 20 % (Awogbemi, 2008).

1.1. Aim of the Study

The aim of this paper is to assess the current status and opportunities for reducing water use and wastewater generation in the Nigerian brewery industries through a cleaner production approach and by using the *Water Audit Tool* developed by UNEP. The study also focuses on sector study and framework analysis of water consumption in two purposively selected breweries under different management bodies.

1.2. Objectives and Scope

This study was undertaken as part of the African Brewery Sector Water Saving Initiative (ABREW). Specifically, the study assessed the needs and opportunities for reducing water use and wastewater generation from the brewery sector in Nigeria, by applying the cleaner production approach.
The overall objectives of this Life Cycle Assessment study are to:

(a) Minimize the volume of wastewater generated in the brewery industries;
(b) Assess the potential environmental effects of the different stages of the beer life cycle;
(c) Check the environmental performance at the brewery;
(d) Investigate the methods of storage, collection, transportation and final disposal of wastewaters in the industries; and
(e) Assess the relative effectiveness of the management methods.

1.3. Justification of Research

The study will provide data on the sources of water, compositions, generation, rate, handling and storing practices and wastewater generated in within the Nigerian Brewery Industries. This will serve as a valuable tool for uncovering inadequacies and the associated menace and a good basis for setting regulations and policies for water use in brewery industries.

There has been a lot of water wastage on daily basis in the production and distribution of brewery products. This problem can be traced to:

- ✓ Insufficient water monitoring at plant level;
- ✓ Environmental control seen as issue of wastewater treatment, not improving production efficiency;
- ✓ Limited understanding of cleaner production (CP) approach;
- ✓ Management unaware of concomitant costs associated with high water use, e.g. energy costs, higher chemicals use, costs of pumping and treatment; and
- ✓ Limited information on national water use compared industrial use with agricultural and domestic use. Pasteurization uses heated water but mostly this is circulated and thus used repeatedly (UNEP, 2006).

The study will also contribute to the limited number of literature on assessment of water use and management issues in Nigerian Brewery. A typical water losses from pasteurisation processes is shown in Figure 1.

Figure 1: Water losses from the pasteurizer pipe A

Historically, different regions have become famous for their classic beer styles as defined by the waters available for brewing. For example, the famous brewing waters from the deep wells at Burton-on-Trent are known for their excellent qualities in brewing full-flavored pale ales. Burton water is high in permanent hardness because of the high calcium and sulfate content, but it also has a lot of temporary hardness from a high level of bicarbonate. Munich water is poor in sulfates and chloride but contains carbonates, which are not very desirable for pale beers but ideal for producing darker, mellower lagers (Olafimihan, 2005).

The modern brewery can produce a stable product even though raw materials, plant types and the scale of operation are changing. It is time to take our use of water much more seriously. It is the lynchpin of our survival on this planet and if we are to have any success at all in preserving our planet for ourselves and those to come, how we manage water is essential to that success and preservation (Taylor, 2006).

Table 1 gives Water use in breweries of some African countries. **A**frican **BRE**wery Sector **W**ater Savings Initiative (ABREW) aimed at assessing the current status and opportunities for reducing water and wastewater generation in African brewery sector through cleaner production approach. Sector study and framework analysis of water consumption in African breweries focused on the situation in Ethiopia, Ghana, Morocco and Uganda.

Breweries in Ghana, Morocco and Uganda compete for water with other industrial and domestic uses. In Ethiopia breweries contend with irrigation for crop farming. Minimal or no treatment of wastewater affects receiving water bodies and threatens water supplies of other users. Acute shortage of fresh water in urban centres and dependence of nearby rural communities on rivers is already source of conflict and dispute in most African countries (UNEP, 2013).

2. Water Treatment Plant in Ibadan Brewery

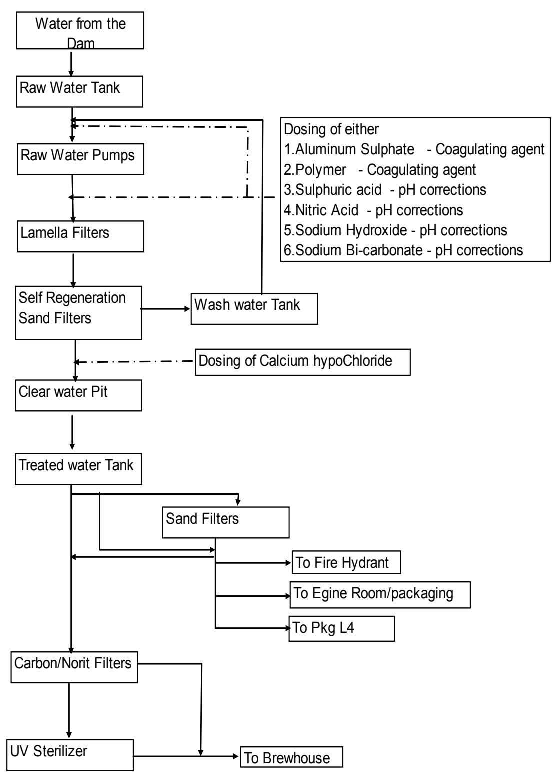
There are three main sources of water to Ibadan Brewery namely:

1. Underground water (Bore hole)
2. Surface Water (River, stream and lake)
3. Public supply

Figure 2 indicates the flow process diagram of Ibadan Brewery Water Treatment. Plant The brewery uses surface water more than other sources. The government charges N30.00 on every 1m^3 of raw water (untreated) pumped into the tank (Oyebode, 2010).

Table 1. Water use in breweries of some African countries

Country	Total annual production (hl/year)	Total annual water consumption(hl/year)	Specific water use (hl water/hl beer)
Ethiopia (5 companies)	1.5 million	20 million	9.0 – 22.0 average 13.0
Ghana (4 companies)	1.3 million	12 million	7.4 – 9.5
Morocco (1 company)	0.9 million	Not available	Not available
Uganda (2 companies)	1.5 million	12 million	7.2 – 9.0
Total	5.2 million	> 44 million	



Source: Taylor (2006).

Figure 2: Flow Process Diagram of Ibadan Brewery Water Treatment Plant

2.1. Raw Water Pump

There are two pumps that pump the water from the raw water tank to the Lamella separator filters. The water from the raw water tank flow by gravity to the pump while the pumps suck and pump into the Lamella separator filters at about 5 bar.

Between the pumps and the Lamella separator filters, again aluminium sulphate and polymer are dosed to coagulate the flocs and dirt. While aluminium sulphate coagulates into smaller particles, polymer aid coagulation into bigger particle for easy filtration at the Lamella separator/sand filter. Hydrochloric and Nitric Acid are also dosed for pH correction when it tends towards alkaline, while Sodium Hydroxide and Sodium Bi-carbonate are dosed for pH correction when it tends towards acidic. Figure 3 gives the Cross section of the Pumps in the Treatment Plant.

Figure 3: Cross section of the Pumps in the Treatment Plant

3. Materials and Methods

3.1. Preliminary Activities

Preliminary activities involved collection and grouping of data and selection of samples.

3.1.1. Collection, grouping and selection of available data

The lbadan Plant of the Nigerian Bottling Company Plc which is a multi-nationally owned public listed Brewery and Standard Breweries Plc, Ilesha which was formerly a privately owned brewery but recently listed as a Public Company were selected for the survey. Data on production for a number of years from each Brewery were randomized to select a set of annual reports that was averaged and used in the analysis.

3.2. Administration of Designed Questionnaires

Questionnaires as designed in ABREW were administered to each of the selected breweries to collect information on:

(i) Name of brewery plants and management responsible;
(ii) Types of water sources and volume from each source;
(iii) Types of products in the plant;
(iv) Typical wastewater generated from each department
(v) Quantities of wastewater generated per day.
(vi) Methods of storage, collection, transportation and final disposal being used in managing the wastes from the brewery
(vii) Authority responsible for wastes management.

3.3. Field Study

A field study was carried out for collection of data in Nigerian breweries Ibadan and Ilesha brewery. This involved using the techniques of oral interview, questionnaires, researchers' observation strategy and physical involvement in each of the production processes especially the water supply, water treatment facilities utilisation and wastewater disposal in Ibadan and Ilesha breweries. The primary facilities and the specialized services were based on the questionnaires and researchers judgement quality.

Questionnaires were supplied to each department to obtain relevant data. Results from questionnaires and field study were analysed and quantities of water use and wastewater generated per day in each of the two breweries were obtained with reference to production processes. This was used to estimate the quantity of water use and wastewater that will be generated by these industries yearly.

3.4. Assessment of Existing Handling Methods

The existing methods of each elements of handling were assessed and the reports were evaluated. It was during this assessment that photographs were taken and compiled.

From the assessment and evaluation, an option for a safe management of the wastes was developed. The methodology of the assessment is derived from the CP manual from UNEP: Environmental Management in the Brewing Industry (Technical Report No 33). The purpose of CP is to continuously reduce consumption and emissions from production processes, products and services. The preferred CP option is reduction of waste at source. Upgrading a brewery in order to implement CP, requires action in three areas that are interrelated as illustrated below. Action in one area without taking complementary action in the other two areas may greatly reduce its effectiveness.

Critical analysis must be done on engineering, plant, equipment, training, High Consumption Breweries and Low Consumption Breweries.

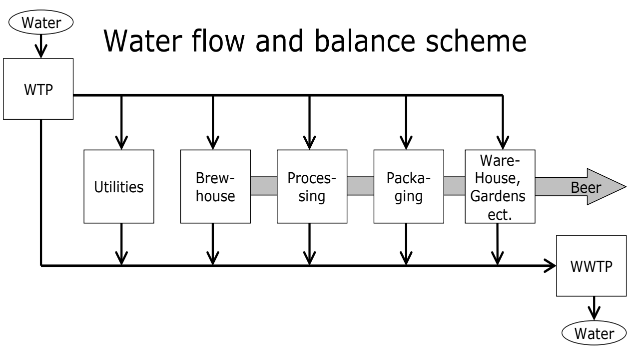
3.5. Method of Collecting Data

Questionnaires were distributed to various staff in Ibadan and Ilesha brewery in order to extract relevant data that will enhance the life cycle assessment of water use in Nigerian breweries. Some of the questions are in the Appendix I. High Consumption Breweries can immediately achieve substantial reduction by addressing management issues and small changes in ancillary operations and process systems. Low Consumption Breweries need to begin focusing on all three functional groups in detail. Preliminary activities involved collection and grouping of data and selection of samples after site visitation and the process of a CP-assessment as described in Technical Report No 33 was used. The *Water Audit Tool* for Breweries was used. This tool supports the water assessment of a brewery by preparing water balances for the relevant functions and calculating theoretical potentials for savings. It is a software made from Microsoft excel with column for Input, Model and Output data.

3.6. Guides for Water Audit Tool

The purpose of the Water Audit Tool is to provide a guide line for the water balances in each part of the process. This requires a process overview, measurements for the relevant parameters and benchmarks. With this information potential water saving can be calculated for each part of the process in order to focus the effort to save water. But the tool also supports the decision process of implementing water saving initiatives by calculating the value of the water saving.

The brewing process is described generically in the Technical Report. The generic process also includes other inputs than water and it includes the malting process. For the purpose of an Audit with focus on water usage, +B107 the holistic process from Technical Report needs to be simplified. This is illustrated below in the schematic layout of a brewery. A further simplification of the water flow is illustrated in Figure 4 and is the platform of the Water Audit Tool, which is used in the water CP-Assessment of each brewery.



Source: Norton (2005).

Figure 4: Water flow and Balances Scheme

For each of the functions in the process a water balance can be made that defines

1. Input of water
2. Output of beer
3. Output of beer loss
4. Output of waste water
5. Quality of waste water (kg. COD/HL) (only total)

The actual readings can be compared to benchmarks and potential saving can be calculated as the difference between the actual and the benchmark. The focus area of the in-plant assessment\should be where the largest potential saving exists. In order to motivate a water saving effort the water savings are theoretically converted into amounts. This is done in two perspectives; the input / output perspective and the Beer loss perspective.

The input/output perspective is based on the assumption that efforts to reduce water consumption at the brewery will also result in saving of other consumptions and of cause in lees output of waste water. A major input to the brewery is energy that is used to circulate the water around and both to cool and to heat the water. The water audit tool calculates the potential saving on energy by a simple extrapolation between the low and high consuming benchmarks. This approach is use on malt and adjunct, energy, fuel and waste water and the price of all these input and output are therefore part of the data collection. It could be argued that workforce should also be included as well as the cost of the equipment, but the aim is to keep the model as simple as possible and secondly to stay in line with the input/output definitions of the UN Technical Report No 33.

The beer loss perspective is relevant in the sense that beer loss is also loss of water and that the value of beer is quite high since it's the product of all the inputs to the process.

Both perspectives are based on the assumption that a reduction in water usages will result in reductions according to benchmarks in other fields of the process. This is a very rough assumption, but experience with Lean manufacturing shows that such rough simplifications work. Lean manufacturing is also based on an assumption that focusing on waste and continuous improvement will reduce cost. Secondly the model can be used for ongoing monitoring of water consumption and discharge at a brewery in order to support continuous improvement.

The main menu of the model is the Gateway sheet, from where all the sheets of the model can be accessed quickly and easily. Furthermore, the Gateway sheet provides a simple overview of the model in terms of how the model works, and if all required input data has been entered. The main input sheet of the model is the Readings sheet, where the volumes of water can be entered month by month. In order to compare actual with the targets for the brewery there is an input sheet for the targets. The value of the savings is calculated from the unit prices that can be inputted in the Unit Price sheet. In order to have the right information on prints, information about the company should be entered in the Input Sheet.

In the model section there are 3 sheets. The calculation and principles of the model are illustrated in the Water Flow sheet. The Time Series Sheet has the same calculations but in a format that is usable for the charts in the output section. The Benchmark sheet is where the Benchmarking numbers are pre-entered. The output section contains a benchmarking report that compares the actual with the values from low consumption breweries. The report also calculates potential savings in volumes as well as values. The Follow Up report works the same way but with the Target number of the brewery instead of benchmarking numbers. The Graphics sheet contains charts of showing development in water consumption for each function in the brewery in a 2- year time frame.

The output section is controlled by the two input fields on the Gateway sheet. Here the currency for all Output report can be determined as well as the period that shall be reported. All reports including the water flow can be printed in one operation by using the “Print Outputs and Water Flow” button.

The documentation section contains information about how the model should be used and operated.

Pale blue fields are input fields. Purple fields are calculated fields. Grey fields are summaries or headlines. Description of the sheets

The sheets in the model are structured in four groups: Input, Model, Output and Documentation. The Input sheets provide data for the Model sheets that provide data for the Output sheets. Appendix II indicates guide for water audit tool and Figure 5 shows the water beer ratio for various uses.

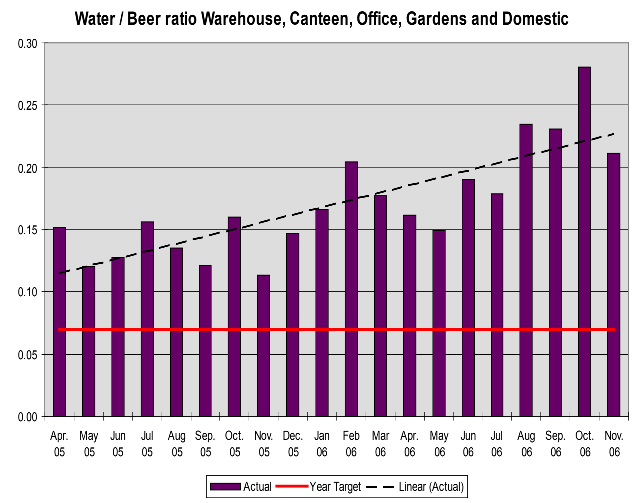


Figure 5: Water/ Beer ratio for various uses in Ibadan and Ilesha Brewery

4. Data Analysis and Results

In the two breweries used as case study, the life cycle assessment of water use conducted indicates that there is need for improvement of water supply and wastewater treatment. Figures 6-8 show major units in the Breweries where water use can be controlled.

4.1. Water use In Ibadan and Ilesha Brewery

In the two breweries used as case study, the life cycle assessment of water use conducted indicates that there is need for improvement of water supply and wastewater treatment.

To facilitate the data collection procedure, this study brings to greater prominence the situation of the African brewing industry with respect to water use. The cleaner production approach is known to dramatically reduce resource consumption while at the same time increase process efficiency. Improved efficiency also has positive financial implications as it means less money wasted on valuable resources released to the environment. These simple and seemingly obvious facts raise the key question of why this is not occurring automatically in the industry without the stimulus of outside intervention. Cleaner production has the potential to make a major contribution to reducing water consumption in African breweries.

Figure 6: Gauge Meter for the Water Treatment Plant

Figure 7: Pasteurizers and Water Treatment Plant

Figure 8: Cylindrical Container and Meter for the Treatment Plan

4.2. Evaluation of Effectiveness of Existing Water Use

The existing water uses for the two breweries were assessed and the reports were evaluated. It was during this assessment that photographs were taken and compiled. Adequate data were obtained to allow for more detailed decision-making at all levels to solve the problem that can influence water use. Hydraulic machinery such as pumps and turbines, hydraulic controls such as valves are necessary for effective distribution of water and to prevent water losses.

At the regional level, there will be business framework for information exchange or technical cooperation. A typical overview of Statistical Data on Efficiency of water use in Ilesha Brewery and other important details about the treatment plant units shown in Figures 6 -8 is presented in Tables 4 -8.

Table 4: Statistical Data on Efficiency of water use in Ilesha Brewery

Week	Filler efficiency %	Overall efficiency %	total stops %
1	52.3	36.5	30.0
2	53.1	40.0	24.4
3	54.5	41.9	23.2
4	47.6	29.8	37.3
5	41.6	20.8	40.5
6	53.7	34.0	36.7
7	48.7	38.1	21.7
8	47.3	33.9	28.6
9	47.6	32.6	31.6
10	40.9	29.5	27.8
11	42.0	26.7	36.5
12	47.8	32.5	32.0
13	41.1	32.9	19.9
14	35.5	15.1	48.6
15	27.8	16.1	32.0
16	32.0	24.0	24.9
17	28.8	14.8	35.3
18	32.0	17.1	46.7
19	37.2	24.4	34.3
20	39.3	28.4	27.7
21	40.7	29.2	28.2
22	38.3	27.6	27.9
23	43.7	27.9	36.3
24	42.5	26.4	38.0
25	43.4	31.3	27.9
26	47.0	29.8	36.6
27	39.4	34.7	12.1
28	39.2	29.81	24.1
29	40.32	30.3	25.0
30	31.02	23.9	23.0
31	34..40	26.25	23.7
32	43.69	27.0	38.25
33	41.95	27.64	34.1
34	40.7	31.9	21.7
35	45.11	33.1	26.6

Source: Oyebode (2010)

Table 5. Weekly Production and Stock Report in the Brewery

		Brewery 1	
	Actual	Target	Difference
		2006	
	762,220	762,220	-
Utilities	552,445	266,777	285,668
Brewhouse	2,360,826	1,333,885	1,026,941
Beer Processing	626,861	1,547,306	-920,446
Packaging	2,343,332	2,134,216	209,117
Warehouse ect.	146,425	53,355	93,069
	6,029,888	5,335,539	694,350
Wastewater in HL	4,926,354	2,667,769	2,258,584
COD in Waste water mg/l	1,560	4,286	2,726
BOD in Waste water mg/l	1,040	2,286	1,246
Brew house	9,909	7,622	2,287
Processing	39,635	19,055	20,580
Packaging	13,720	11,433	2,287
Warehouse	0	381	0
	63,264	38,492	25,153
	Ratio per HL of Beer. 2006		
	Actual	Target	Difference
		2006	
Utilities	0.72	0.35	0.37
Brew house	3.10	1.75	1.35
Beer Processing	0.82	2.03	1.21
Packaging	3.07	2.80	0.27
Warehouse etc.	0.19	0.07	0.12
	7.91	7.00	0.91
Wastewater in HL	6.46	3.50	2.96
COD kg	1.01	1.50	0.49
BOD kg	0.67	0.80	0.13
Brew house	0.013	0.010	0.003
Processing	0.052	0.025	0.027
Packaging	0.018	0.015	0.003
Warehouse	0.000	0.001	0.000
	0.083	0.051	0.033

Source: Oyebode (2010)

Brewery COD emissions are not high due to the effective municipal wastewater treatment plant that treats the brewery's wastewater.

Table 6. Annual brewery production in Ibadan Brewery

	Star	Gulder	Legend Big	Legend Small	Maltina	Amstel	Fayrouz Apple	Fayrouz Pear
Bottles	747182	383332	147595	44391	135747	42038	57203	38829
Can	109749	52555	na	Na	199461	97872	48887	35693

The brewery annual beer production stood at 1,490,863 hl with off peak period being June to August
Soft drink production
The brewery annual soft drink production stood at 655,731 hl
With off peak period being June to August
Line 4 = 30000 Bottles per hour (Big bottles)
Line 5 = 28000 Bottles per hour (Big bottles)
Line 6 = 36000 Cans per hour.
OPI = Line Output X Man time / Nominal speed
Tunnel pasteurizer in use and is use for all brand

Table 7. Data on Losses per brand

Quarter	Result %	star	Gulder	legend	Maltina	amstel	FayrouzAple	Fayrouz Pear
1	4.31	2.39	4.48	10.52	3.86	3.99	6.58	4.89
2	5.72	1.85	6.89	11.36	5.65	5.68	7.5	8.81
3	4.10	1.79	9	7.8	1.45	2.44	2.4	4.29
4	3.48	2.23	7.04	5.74	2.41	2.40	2.46	2.30
2009	4.44	2.07	6.75	8.5	4.26	3.54	4.5	5.43

Table 8. Annual brewery production

	Star	Gulder	Legend big	Legend Small	Martina	Amstel	FayrouzAple	Fayrouz Pear
Bottles	747182	383332	147595	44391	135747	42038	57203	38829
Can	109749	52555	NIL	NIL	199461	97872	48887	35693

Source: Oyebode (2010)

Ilesha Brewery used to obtain raw water from Esa-Odo Dam and they have all their drainage and liquid wastes discharged to a big reservoir and then off via a DN 200 PVC pipe to the nearest ditch

5. Conclusions

Based on the field study, investigations and physical assessment conducted during this research, the following conclusions have been drawn:

1. A general observation is that despite much previous activity in other parts of Africa, Cleaner Production Initiatives as enforced by National Cleaner Production Centres (NCPCs) of other countries is not available in Nigeria (the study area);
2. The Breweries studied and by induction, other breweries and beverage industries in Nigeria are consuming water in excess of standard practice and recommendation due to poor housekeeping and process management;
3. Older technologies that are inefficiently operated can easily double or triple this consumption, to the detriment of neighboring communities in particular other users, and additional cost to the company itself;
4. High water consumption beyond the recommended limit also means higher energy use, as much of the excess water has to be heated in the brewing and cleaning processes;
5. There is the need for beverage industries to adopt the use of Water Auditing Tool to reduce impact on available water.

The conclusions of this study are likely to apply to most African countries, as improved water management is an important objective across the entire continent. The efficiency levels of Nigerian breweries can at best be described as medium, with rather wide variations in and between countries and breweries. Water consumption and specific use (hl water / hl beer) varies greatly between individual breweries in the study locations. Most breweries are still far from the accepted international best practice benchmark level of 6.5 hl/hl, let alone the best technology level of 4 hl/hl. Therefore there are many opportunities for improving water use efficiency. The study highlights that improvements do not always need large financial investments, and that simple housekeeping and minor plant changes can often produce significant reductions in water use (and effluent volume). Planned increases in beer production will exacerbate this competition with other (growing) water uses. Nevertheless, awareness is still limited among the main partners – company, government, and public – about the need for water savings in breweries, and of the best way of achieving them. Environmental control is still often seen as an issue of wastewater treatment rather than improving production efficiency, even though many studies have shown the latter to be more cost-effective to affected companies. The concept of reducing waste flows before building treatment facilities has yet to take a firm hold in the mindset of industry managers. At this moment, the primary driver for reduced water consumption and pollution reduction are the corporate environmental policies of the multinational companies active in the brewing industry, and even then, these policies are not always implemented to their full extent.

5.1. Recommendation

Therefore there are many opportunities for improving water use efficiency. The study highlights that improvements do not always need large financial investments, and that simple housekeeping and minor plant changes can often produce significant reductions in water use (and effluent volume). Water footprint tools to determine areas of water stress and water need to be publicized amongst industries as a means of improving their corporate social responsibilities. Target audience for such awareness drive includes the companies, government agencies, and the public. Environmental control is still often seen as an issue of wastewater treatment rather than improving production efficiency, even though many studies have shown the latter to be more cost effective to the company. At this moment, the primary driver for reduced water consumption and pollution reduction are the corporate environmental policies of the multinational companies active in the brewing industry, and even then, these policies are not always implemented to their full extent.

In view of the aforementioned, it is necessary to give the following recommendations so as to enhance the optimum ways of managing wastewater disposal and water use in Nigerian brewery industries:

1. Research into water auditing and water footprint of major water consumers should be encouraged.
2. Government to make better use of financial instruments as a means of reducing water wastage, e.g. water abstraction and discharge fees or polluter pays policy;
3. Develop comprehensive follow-up programme to ensure more focussed and prolonged CP outreach to brewery sector and promote public-private partnership on water utilisation in African breweries;
4. Increase awareness raising in all stakeholder groups (companies, government, public) on national importance of improved water management in each country;
5. Improved information on water allocation, water use and discharge to allow for effective application of government policy;
6. Promote CP as process enhancement tool;
7. Introduce optimal pricing for water extraction and discharge; and
8. Enforce existing environmental regulations to protect the environment and reduce water stress index.

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REFERENCES

[1] Awogbemi I. O. A. (2008): The urban planner and the management of Nigerian Cities. The lessons of experiences, In: Waheed K. A. (Ed), Reflection on Nigerian urban planning issues. Desi-Ogga Publishers, Lagos.

[2] Ayatse, J.O, Eka, O.U. and Ifon, E.T. (2005): Chemical evaluation of the effect of roasting on the nutritive value of maize. Food Chemistry. African Journal of Food and Nutritional Sciences: Volume 5 No 2, Lewis Publishers/CRC Press, Inc. Florida.

[3] Harlander, S.K and Labuza, I. (2006): The Brewing Process. In: Biotechnology in Food Processing, Chapman-Hall, Ltd. University Press, London.

[4] Norton, J. W, (2005). Environmental Balance: Norton incinerator specifications. Online: http://www.environmentalengineering.net/incineratorsspecs.php

[5] Olafimihan, O.A, (2005). Oral Interview Wastes Management Practice At Nigerian Brewery, Ibadan.

[6] Osho, M and Dashiell, K (1997): Expanding Soya bean production, processing and utilization in Africa(1997); Online at http://www.iita.org

[7] Oyebode, O.J. (2010): Assessment of Waste Water Management in Ibadan and Ilesha breweries. (2010) Unpublished (M.Sc. Project) in the University of Ibadan.

[8] Taylor, T.G.(2006): "The Impact of Water Quality on Beer Quality. Handbook of Brewing, edited by Fergus G. Priest

and Graham G. Stewart. Boca Raton, Florida: CRC Press, New York.

[9] United Nations Environment Programme (Industry and Environment) ABREW: (2006): Framework Analysis Country Report for ABREW in Ghana, Uganda, Ethiopia and Morocco.

[10] United Nations Environment Programme for Industry and Environment (2008): Cleaner Production – a training resource package, First Edition, ISBN 92-807-1605-0. http://www.unep.fr/pc/cp/library/training/cptraining/All%2c0hapters.pdf http://www.unglobalcompact.org/Issues/Environment/Water_sustainability(accessed15 July 2008).

[11] United Nations Environment Programme (2013):On UNEP's activities on sustainable consumption and production and 10 YFP. http://www.unep.fr/scp (accessed 14 Nov 2013).