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Application of Statistical Quality Control on AdaPoly Sachet Water, Adamawa State Polytechnic, Yola Nigeria

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Abstract **- It is a well-known fact that Variation is a basic law of nature in a production process, while Statistical Quality Control is a statistical techniques designed for measuring, monitoring, controlling and improving or eliminating variation in a production process. Hence, this study aimed at determines the Statistical Quality Control of AdaPoly Sachet Water, Adamawa State Polytechnic Yola. The study used cross-sectional design with quantitative approach. A primary data was obtained from the production site of Adapoly Sachet Water for a period of four hours. Each hour, 20 samples of Adapoly Sachet Water were randomly selected, weighed and recorded. The study used $\bar{X}$Chart and R-Chart of 3δ-control limits to determine the statistical quality control of the production process. The result revealed that both the $\bar{X}$ Chart and R-Chart of the 3δ-control limits fall within the range of lower and upper control limits, indicating that the production process is under control. Since production process has no chance and assignable causes of variations, the management of Adapoly Schact Water need to maintain this quality standard. The management should also expand the production and improve on their marketing strategies in order enhance and boost the internally generated revenue of the institution.**

Keywords: Quality Control, Control Chart, Sachet Water, Variation, $\bar{X}$ Chart, R-Chart and 3δ-control limits.

1. Introduction

AdaPoly Sachet Water was established on 26th May, 2014 by the then Rector of Adamawa State Polytechnic Yola, Professor Umar Bobboi with the saddled responsibilities of providing clean and safe water to other departments of the Polytechnic and also to operate a commercial unit purely designed to boost the internally generated revenue of the institution (Spy, 2016).

Water is a transparent fluid that forms streams, lakes, oceans, and rain and is the major constituent of organisms' fluids. It is an inorganic, odourless, tasteless, and transparent substance made up of hydrogen and oxygen existing in gaseous, liquid, and solid states (Zumdahl, 2020). Water covers 71% of the earth's surface and is vital for all known forms of life. The instant development of developing nations includes having a more significant population of people who can improve water and improve health. However, 1.2 billion people worldwide do not have access to clean and safe water, and most of these people are in developing countries (Amaechi, 2016 & Jidawna et al., 2014).

Water packaging industries are the most common industries located in cities, towns and even villages in Nigeria. These industries are great employers of both unskilled and semi-skill workers in addition to provision with clean and safe drinking water to Nigerians. The quality of water supplied by these industries to their respective consumers is carefully monitored and maintained by the National Agency for Food and Drug Administration and Control (NAFDAC) by examining and certifying their regular activities through quality water analysis, regular fumigations of factory and its environment, medical tests of factory workers, uses of correct water packaging polythene materials (Sadiq & Adeyemi, 2012).

Quality control means the statistical and engineering method use in measuring, monitoring, controlling and improving quality product, while Statistical quality control is the application of statistical techniques to problem associated with the quality of the products. It can also be defined as the regulatory process through which we measure actual quality performances, compare with the standard and act on the difference (Demekpe, 2011).

Statistical Quality Control can also be defined as an economic and effective system of maintaining and improving the output throughout the whole operating process of specification, production and inspection based on continuous testing with random samples. Over the years, people refer to Quality Control as the inspection of finished products, meaning to check whether they meet the desired requirements and specifications. Although it is not just limited to inspecting products as it might also include detecting the cause for non-conformities. Statistical quality control is mostly used in manufacturing industry where these techniques are used to regulate and analyze the variation of industrial process. The

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major reason why regulating process is very necessary in production is that the product produced meets the desired specification for which it is made (Asogwa & Eze, 2022).

Variation in quality production can be attributed due to chance and assignable causes. Chance variations are usually large in number, randomly inherited in nature and cannot be eliminated unless there is a major change in equipment or material. Internal machine friction, slight variations in materials or process conditions, atmospheric conditions and vibrations transmitted to a machine are all sources of chance causes. Assignable is usually are non-random in nature and be eliminated or reduced. These causes can be identified and generally be related to variation in the production processes themselves. Mechanical fault, faulting raw materials, differences in operators are all assignable causes of variation in a production process (Gabriel, 2022).

The primary tools used for statistical quality Control is the control chart, a graphical representation of certain data collected or recorded for specific quantitative measurements of the manufacturing processes are tracked on various control chart in comparison to their sampling distributions. Different types of control chart that can be used to test for the causes of these variations are $\bar{X}$-Chart, R-Chart, P-Chart, and C-Chart, these entire chart represent how quality characteristics change values from one sample to another. Measurable or continuous attributes or variables can be accessed by plotting either the mean of the measurement ($\bar{X}$-Chartor the range of the measurement (R-Chart). C-Chart may also be used when the characteristic representing the quality of products is discrete and P-Chart when considering proportion of defectiveness in the sample means (Asogwa & Eze, 2022).

It is well noted that variations in the state products such as length, diameter, thickness, weight, volume, and density are due to the variability that occurs in machines, tools, raw materials, and human operators. The presence of this unavoidable change and the interchangeability result in specifying limits for the variation of any quality characteristic, which are the specifications required by the customer (Montgomery, 2007).

Terna et al., 2020, in a related study to investigate the application of statistical quality control in monitoring the production, packaging and marketing process of sachet water revealed that; the control chart for 30 days' investigative fractional defective with a 99.73%confidence level indicates that the production processes of the sachet water for 12 days were found to be out of statistical control.

2. Objective of the Study

The objective of this study is to determine the Statistical Quality Control of AdaPoly Sachet Water of Adamawa State Polytechnic, Yola.

3. Literature Review

Studies have shown that; about 1.2 billion people around the world lack access to clean and safe water, while close to 2.5 billion are not provided with adequate sanitation. The standard industrialized world model for delivery of safe drinking water and sanitation technology is however, not affordable in much of the developing world. Thus, given the renewed global commitments towards the Millennium Development Goals (MDG) marked for 2015, the importance and contribution of locally sourced low cost alternative drinking water schemes to sustainable access in rural and semi-urban settings of developing nations cannot be over emphasized (UNDESA, 2004).

Water is essential for sustenance of life, and it needs to be available, accessible, and affordable in its purest form. Borehole and sachet water may seem clean, but they may contain potentially harmful contaminants from aging pipes and production processes. Drinking water is potable and safe for drinking if it is free from physical, chemical, and microbiological contaminants (Ogoko, 2017). Despite the Nigerian government's interventions to alleviate water contamination, a considerable number of Nigerians are still without potable water (Shigut et al., 2017). Less than half (48%) of residents in semi-urban and urban areas and 39% of rural dwellers have access to potable water in the country (Onyenechere & Osuji, 2012).

Statutorily, portable water supply in Nigeria had been by the Government Owned Public Water Utilities in the past. The Government Owned Public Water Utilities provided their supply from conventional water treatments plants that uses water from impounded reservoirs, flowing perennial streams, lakes and deep boreholes. As the country population grows and industries increase, the supply of water by the Government Owned Public Water Utilities becomes inadequate in quality and quantity. This led to the emergence of some Privately Owned Water Enterprises that operated side by side with the Government Owned Public Water Utilities within the water sector (Onemano & Otun, 2003).

One of the most popular Privately Owned Water Enterprises in Nigeria is the sachet water sold in polythene sachet otherwise called 'Pure Water'. The Privately Owned Water Enterprises mainly collect their water as the end product of initially treated water supplied by the Government

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Owned Public Water Utilities and do little treatment such as the removal of the suspended solids to make the Government Owned Public Water Utilities more potable. They also do some minor treatment on water from natural springs, open wells and deep boreholes. Some also collect water directly from the Government Owned Public Water Utilities kiosks and later resells them at a higher price (Terna at el, 2020).

The production, marketing and consumption of sachet water have increased tremendously. There are now several brands of these type of packaged water marketed in Nigeria and other developing nations (Ogan, 2009). This so called Pure Water in sachets is readily available, easy to serve and the price is affordable and finds patronage from the middle class and members of low socio-economic classes, but there are concerns about its production, purity, packaging and distribution (Terna at el, 2020).

After the industrial revolution, companies began manufacturing products using assembly line in factories. Rather than one person being responsible for a single product from start to assembly line, each worker was responsible for a single part of the product, as products become more complex. The workers were trained to perform on specific task in the manufacturing process. For example, in the production of an electric motor, one person would be responsible for winding the armature, another person for casting the gears, a third person for assembling the motor, and so on. To ensure that the manufactured product perform the satisfactory, companies trained some people to inspect the finished products. When poor performance was detected, it was necessary to find the cause and correct it. During the 1930s and 1940s, Walter A. Shewert, working for bell telephone laboratories developed a process for checking each part of the manufacturing process and making any corrections needed before the product was assembled rather that checking the final product, thus saving time and money. This process is known as Quality Control and it uses small samples and a control chart. Sometimes called a statistical process control chart or a quality control chart. The control chart uses means, medians, ranges, or standard deviations of certain measurements of various part of the product to detect deviations from the norm (Demekpe, 2011).

Control chart is a statistical device principally used for the study and control repetitive process. The idea of control chart was initially proposed by a statistician called Shewart,, W. H. in 1931 which consist of a central and two pairs of limit line spaced above and below the central line, these lines are usually term as upper and lower control limits (Gabriel, 2022).

Sadiq & Adeyemi 2012, in a related study to investigate the quality control in a water packaging industry revealed that; the water produced during the period under investigation (86 days) were out of statistical quality control with 24 points (twenty-four days). He further explained that; the final revised control chart based on 99.73% level of confidence after discarding the 24 points, the remaining 52 points (days) fall within the range of lower and upper control limits, indicating that the process is under control.

Asogwa & Eze 2022, in a study to investigate the application of Statistical Quality Control on Nigeria Malt Drink, explained that the chart plotted for the net-weight of the product are within the lower and upper control signals, showing that the attribute under investigation is in control.

Terna at el, 2020, also in a related study to investigate the application of statistical quality control in monitoring the production, packaging and marketing process of sachet water revealed that; the control chart for 30 days' investigative fractional defective with a 99.73% confidence level indicates that the production processes of the sachet water for 12 days were found to be out of statistical control.

4. Methods and Materials

The research design used in this study is cross-sectional design with quantitative approach. A primary data was obtained from the production site of Adapoly Sachet Water for a period of four hours. The data consist of 20 samples of Sachet Water that were randomly selected, weighed and recorded for each hour.

The study used both$\bar{X}$-Chart (mean) and R-Chart (range) of 3δ-control limits to determine the statistical quality control of Adapoly Sachet Water.

The mean of means ($\bar{\bar{X}}$), mean of ranges ($\bar{R}$) and standard deviation ($\delta = \hat{\delta}_n$) can be express as:

$$\bar{\bar{X}} = \sum_{i=1}^{n} \bar{X}_i / n \quad (1)$$

$$\bar{R} = \sum_{i=1}^{n} R_i / n \quad (2)$$

$$\delta = \hat{\delta}_n = \bar{R} / d_n \quad (3)$$

Hence, using equation (1), (2) and (3), the mean of means ($\bar{\bar{X}}$), mean of ranges ($\bar{R}$) and standard deviation ($\delta = \hat{\delta}_n$) were obtained as:

$\therefore \bar{\bar{X}} = 432.99$

$\therefore \bar{R} = 33.20$

$\therefore \delta = \hat{\delta}_n = 16.13$

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The Lower Control Limit (LCL), Central Control Limit (CCL), and Upper Control Limit (UCL) of $\bar{X}$-Chart for 3δ-control limits are express as:

$$(Lower\ Control\ Limit)\ LCL = \bar{\bar{X}} - {}^{3\delta}/_{\sqrt{n}} \quad (4)$$

$$(Central\ Control\ Limit)\ CCL = \bar{\bar{X}} \quad (5)$$

$$(Upper\ Control\ Limit)\ UCL = \bar{\bar{X}} + {}^{3\delta}/_{\sqrt{n}} \quad (6)$$

Substituting the values of $\bar{\bar{X}}$ and δ into equation (4), (5) and (6), the Lower Control Limit, Central Control Limit, and Upper Control Limit of $\bar{X}$-Chart for 3δ-control limits were obtained as:

$$(Lower\ Control\ Limit)\ LCL = 408.79$$

$$(Central\ Control\ Limit)\ CCL = \bar{\bar{X}} = 432.99$$

$$(Upper\ Control\ Limit)\ UCL = 457.19)$$

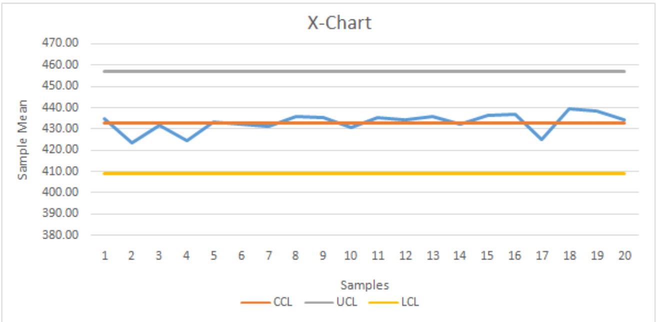

Figure 1: $\bar{X}$-Chart of Adapoly Schact Water

Figure 1 above shows that there is no single point outside the both Lower and Upper Control Limit. This indicates that the production process of Adapoly Schact Water is under statistical quality control.

While the Lower Control Limit, Central Control Limit, and Upper Control Limit of the R-Chart for 3δ-control limits are express as:

$$(Lower\ Control\ Limit)\ LCL = \bar{R} - 3\hat{\delta}_n \quad (7)$$

$$(Central\ Control\ Limit)\ CCL = \bar{R} \quad (8)$$

$$(Upper\ Control\ Limit)\ UCL = \bar{R} + 3\hat{\delta}_n \quad (9)$$

Substituting the values of$\bar{R}$ and $\hat{\delta}_n$ into equation (7), (8) and (9), the Lower Control Limit, Central Control Limit, and Upper Control Limit of R-Chart for 3δ-control limits were obtained as:

$$(Lower\ Control\ Limit)\ LCL = \approx 0.00$$

$$(Central\ Control\ Limit)\ CCL = \bar{R} = 33.20$$

$$(Upper\ Control\ Limit)\ UCL = 81.59$$

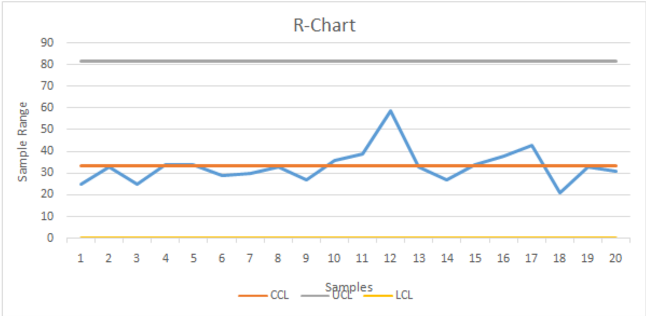

Figure 2: R-Chart of Adapoly Schact Water

Figure 2 above shows that all the points are within the Lower and Upper Control Limit. This implies that the production process of Adapoly Schact Water is under statistical quality control.

5. Discussion of Findings

In a related study by Sadiq & Adeyemi 2012, explained that; the water produced during the period under investigation (86 days) were out of statistical quality control with 24 points (twenty-four days). Meanwhile, this study revealed that both the $\bar{X}$-Chart and R-Chart of 3δ-control limitsfall within the range of lower and upper control limits, indicating that the production of Adapoly Schact Water is under control, hence this implies that the two studies are not in agreement.

Asogwa & Eze 2022, also in a related study to investigate the application of Statistical Quality Control on Nigeria Malt Drink, revealed that; the chart plotted for the net-weight of the product are within the lower and upper control signals. While this study also revealed that the production of Adapoly Schact Water is under control, which implies that the two studies are in agreement.

Similarly, Terna at el, 2020, in a related study to investigate the application of statistical quality control in monitoring the production, packaging and marketing process of sachet water revealed that; the control chart for 30 days indicates that the production processes of the sachet water for 12 days were found to be out of statistical control. On the contrary, this study is not in an agreement with Terna at el, 2020, because this study revealed that; the production process of Adapoly Schact Water for the period under review fall within the range of lower and upper control limits, indicating that the process is under control.

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6. Conclusion

The production process of Adapoly Schact Water is under statistical quality control during the period under review. This is based on the evident that, both the $\bar{X}$-Chart and R-Chart of 3δ-control limits fall within the range of lower and upper control limits. This evident also indicate that production process has no chance and assignable causes of variations. Hence, both the producer and the consumer are at the point of equilibrium.

7. Recommendations

Since production process has no chance and assignable causes of variations, the management of Adapoly Schact Water, Adamawa State Polytechnic, Yola need to maintain this quality standard. The management should also expand the production strategies since their process is under statistical quality control.

The management of the Adapoly Schact Water should improve on their marketing strategies in order enhance and boost the internally generated revenue of the institution.

The management of Adamawa State Polytechnic, Yola should encourage students of relevant/related departments to do their Students Industrial Work Experience Scheme at the Adapoly Schact Water for the students to develop their acquisitions skills.

REFERENCES

[1] Amaechi, F. (2016). Feasibility study report on small scale sachet water production at IsuaniochaAwka North local government area of Anambra State. Retrieved from http://www.academia.edu/36164947.

[2] Asogwa, O.C. &Eze, N.M. (2022). On the Application of Statistical Quality Control on Nigeria.

[3] Malt Drink. BiostatBiom Open Access j. 2022; 11 (1): 555802. DOI: 10.19080/BBOAJ.2022.11.555802.

[4] Demekpe, T.T. (2011). Application of Statistical Quality Control in Benue Cement Company Plc, Gboko Benue State Nigeria. Adapoy Printing Press, Adamawa State Polytechnic, Yola.

[5] Gabriel, A. H. (2022). Application of Statistical Quality Control in Faro Water Bottling Company Plc, Yola Adamawa State Nigeria. Adapoy Printing Press, Adamawa State Polytechnic, Yola.

[6] Jidawna, et al. (2014). Chemical water quality assessment in selected location in Jos, Plateau State, Nigeria. Research Journal of Environmental and Earth Science. ISSN:2041-0484, eISSN:2041-0492.

[7] Montgomery, D. C. (2007). Introduction to statisticalquality control. 6th Edition, John Wiley & Sons, Inc. 2007.

[8] Ogan, M. T. (2009). Microbiological quality of bottled water sold in retail outlet in Nigeria, In.

[9] Dada AC. Sachet water phenomenon in Nigeria: Assessment of the potential health impacts. African journal Microbial Res.2009; 3:15-21.

[10] Ogoko, E. C. (2017). Physicochemical properties and heavy metal concentration of groundwater in Owerri metropolis, Nigeria. Current Journal of Applied Science and Technology, 23(1), 1-10. doi:10.9734/CJAST/2017/35144.

[11] Onemano, J. I.& Otun, J. A. (2003). Problems on water quality standards and monitoring in Nigeria: Towards the millennium development goals. 29th WEDC International Conference, Abuja, Nigeria.

[12] Onyenechere, E. E & Osuji, S. C (2012). Water service provision in Owerri City, Nigeria. Journal of Water Resources and production. http://dx.doi.org/10.4236/jwarp.2012.47058.

[13] Sadiq, I.O. &Adeyemi, M.B. (2012). Quality Control in a Typical Water Packaging Industry. IJPQE Journal, Volume 3 Number 1, page 17-21 January-June, 2012.

[14] Shigut et al. (2017). Assessment of physical-chemical quality of borehole and spring water sources supplied to Robe Town, Oromia region, Ethiopia. Doi:10.1007/s13201-016-0502-4.

[15] Spy Magazine (2020). Adamawa State Polytechnic Yola, Magazine.Adapoy Printing Press, Adamawa State Polytechnic, Yola Nigeria.

[16] Ternaet al. (2020). Application of Statistical Quality Control in Monitoring the Production, Packaging and Marketing Process of Sachet Water. Journal of Scientific Research and Reports • November 2020. DOI: 10.9734/JSRR/2020/v26i930307.

[17] United Nation Department of Economics and Social Affairs (UNDESA).(2004). Urban Agglomerations in Dada AC. Sachet Water Phenomenon in Nigeria: Assessment of the Potential Health Impacts. Afr. J. Microbiol. Res. 2009;3:15-21.

[18] Zumdahl, S. S. (2020). Water. Encyclopedia Britannica. Retrieved from https://www.britannica.com/science/water.

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Appendix

Table 1: Weight (g) of Samples of Adapoly Sachet Water for Four Hours Production

S/No	1st Hour	2nd Hour	3rd Hour	4th Hour	Mean ($\bar{X}$)	Range (R)
1	440	417	440	442	434.75	25
2	408	407	440	438	423.25	33
3	434	417	434	442	431.75	25
4	406	422	430	440	424.50	34
5	437	415	432	449	433.25	34
6	442	413	434	439	432.00	29
7	433	413	435	443	431.00	30
8	446	413	445	439	435.75	33
9	433	420	442	447	435.50	27
10	433	409	435	445	430.50	36
11	450	411	441	440	435.50	39
12	458	399	431	449	434.25	59
13	443	412	444	445	436.00	33
14	434	420	427	447	432.00	27
15	450	416	436	444	436.50	34
16	452	414	436	445	436.75	38
17	419	403	431	446	424.75	43
18	443	428	438	449	439.50	21
19	448	415	448	442	438.25	33
20	448	417	440	431	434.00	31
TOTAL					**8659.75**	**664**

Source: Researcher's Results, 2023

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