



## Assessment of Quality Control of Tiles Production in West Africa Ceramics Company, Ajaokuta, Kogi State

Abdullahi, D.<sup>1</sup>, Lawal S. S.<sup>1</sup> & Abdul, C. I.<sup>2</sup>

<sup>1</sup>Department of Mechanical Engineering, Federal University of Technology, Minna, Nigeria

<sup>2</sup>Department of Architectural Technology, Kogi State Polytechnic, Lokoja, Nigeria

[sadiq.lawal@futminna.edu.ng](mailto:sadiq.lawal@futminna.edu.ng), [danladi4real@yahoo.com](mailto:danladi4real@yahoo.com), [ileanwa@graduate.utm.my](mailto:ileanwa@graduate.utm.my)

Correspondence email: [danladi4real@yahoo.com](mailto:danladi4real@yahoo.com)

### Abstract

Tiles industries has a mandate to comply with total quality management (TQM) process through Standard Organization of Nigeria (SON) for compliant with ISO-9001 certification process for continuous improvement on control, assuring and managing of quality process. The quality tiles require quality performance in industry and it is one of the major issues facing implementation of TQM in industry due to crucial process involved. The study assessed total quality management for producing tiles in WACC, Ajaokuta, Kogi State using ISO-9001:2015. Quality controls of the tiles were assured using P-chart, operation characteristics curve and mechanical resistance test. The performance level of TQM is assessed using correlation approach. Findings of study revealed that TQM in WACC using ISO-9001:2015 Standard indicated implementation level of 71% in year 2022. ISO-9001 based PDCA indicated 69.4% implementation of total quality management on continual project improvement. The compliance rating, P regression equation was:  $P = 4.75x + 57.33$  in which x is year after implementation of ISO 9001:2015. The six major tiles produced by WACC, Ajaokuta require maximum range of 0 to 3 defectives per daily batch production. The operating characteristic curve (OCC) showed that consumers are willing to none defective tiles of 40 x 80, 60 x 60, 120 x 60, 40 x 40, 25 x 40, 30 x 40 sq. cm. The study concludes that continuous improvement of quality standard implementation in WACC, Ajaokuta will boost the performance of tiles management and production.

**Keywords:** Production, Quality Control, Plant Extract, Wistar Rats, Phytochemical Analysis, histopathology

### Introduction

The industrial process requires Total Quality Management (TQM) concept and if employed can make the development and improvement of quality products reliable and it will create added competitive advantage (Awoku, 2012). Most manufacturing companies have found themselves in a great competition for survival. This has driven companies to constantly desire to improve the quality of their products and reduce cost. Many of these companies are ready to make drastic changes according to the demands of the market in order to be ahead of their competitors. In today world market, there is a constant need for maintenance and continuous improvement of quality management (Zu *et al.*, 2010).

Meeting up with constant need for maintenance and continuous improvement of quality management requires TQM implementation practices. This will certainly improve the operational performance of manufacturing industry (Sila, 2007). Nigerian industry often fails to meet the required standards and client or customers' expectations. Thus, such products or services have continued to be plagued by quality issues, which contributes to long-term problems in the Nigerian industry (Ahaotu, 2018). According to (Maik, 2018), this scenario is worse in developing countries such as Nigeria where TQM implementations are not fully adopted. The non- adoption of TQM creates setback in Nigeria industries and this attribute to failing production processes and this affects the product quality (Sahran *et al.*, 2010).

There are several models of TQM which are developed with different principles for achieving quality process in industry. Christensen *et al.*, (2014) identified the following models: Business excellence, Process improvement, ISO 9001, Six sigma, Juran, Demings, Ishikawa, Crosby and Feigenbaum Models.

Nigeria industries has a mandate to comply with TQM process through Standard Organisation of Nigeria (SON) for compliant with ISO-9001 certification process (SON, 2015). This is one of best TQM model known to adopted by the most industries in the world in quality process through International



Organization for Standardization (ISO). ISO-9001 is procedure for continuous improvement on control, assuring and managing of quality process by ISO. ISO 9001 is defined as international standard that specifies requirements for a quality management system (QMS), (ISO 9001, 2015). However, ISO is a standard procedure for assessing TQM processes. TQM is an extension of the quality assurance process beyond the production process that include application of proactive measures that guarantees quality of all the activities of the organisation and her outputs.

The present study tends to assess the implementation of TQM using ISO 9001:2015 in tiles production in which West Africa Ceramics Company Ajaokuta, Kogi State is adopted as case study.

## Materials and Methods

### Materials

The material in this research includes an evaluation checklist and test/measuring instruments and equipment. An evaluation checklist is developed using the requirements stated in ISO 9001:2015 for assessing total quality management (TQM) during production of tiles in WACC, Ajaokuta, Kogi State. The instrument used for different testing includes the following:

- i. Weighing balancing machine
- ii. Universal strength testing machine
- iii. Pendulum Testing machine
- iv. Vickers hardness testing machine

### Methods

The technique for assessing Total Quality Management in WACC, Ajaokuta, Kogi State is in ISO-9001:2015 QMS standard.

The ISO-9001:2015 QMS standard requires the following 10 clauses:

- i. Scope and boundaries
- ii. Normative references
- iii. Terms and definitions
- iv. Organization context
- v. Leadership
- vi. QMS planning
- vii. Support
- viii. Operation standard
- ix. Performance evaluation
- x. Improvement

Clauses 4 to 10 are the seven main clause of ISO 9001:2015 requirement and evaluation for the QMS is in appendix I. The ISO 9001:2015 is based PDCA which are:

1. P is plan: it is based on clauses 4, 5 and 6 which is context of organization, leadership and planning of QMS respectively.
2. D is do: it is clauses 7 and 8 which are support and operation of tiles production in WACC, Ajaokuta
3. C is check: it is clause 9 known as performance process on tile production



4. A is act: it is product and service improvement process which is clause 10

All of the clauses are linked to leadership which is clause 5.

The method adopted for QMS process auditing is based on compliance rating scale of 1 to 5:

1. None compliance
2. Poor compliance
3. Fair compliance
4. Good compliance
5. Excellent compliance

### Quality Control Analysis

The tiles production phases are such as:

- i. Mixing and drying phases
- ii. Forming phase
- iii. Glazing and firing phase
- iv. Sorting and packaging phases

During the sorting and packaging of tiles, quality control process is adopted to select better quality without crack and ill dimension in WACC, Ajaokuta. P-chart was adopted for the analysis.

### Result And Discussion

#### Results

#### Implementation’s Level of TQM in WACC Using ISO-9001:2015 Standard

Table 1 stated the assessment of implementation level of WACC based on ISO-9001:2015 Standard in the year 2022.

**Table 1: Implementation of ISO-9001:2015 Standard in WACC, Ajaokuta.**

Clause No	Sub-clause requirement							Compliance Rating	Compliance Remarks
	1	2	3	4	5	6	7		
4. Context of organization	4	4	4	4	-	-	-	4.00	Good
5. Leadership	4	3	4	4	3	-	-	3.60	Good
6. Planning QMS	4	3	4	-	-	-	-	3.67	Good
7. Support	3	4	4	4	3	-	-	3.60	Good
8. Operation	4	4	3	3	3	3	3	3.29	Fair
9. Performance evaluation	4	4	3	-	-	-	-	3.67	Good
10. Improvement	3	3	3	-	-	-	-	3.00	Fair
Average compliance rating								3.55 $\cong$ 4.0	Good
Implementation based on Percentage								71%	Good

**Note:** None (1), Poor (2), Fair (3), Good (4), Excellent (5). – none clause requirement

The implementation of ISO-9001:2015 Standard in WACC, Ajaokuta was good during period of this research work. The score rating in Table 4.1 showed that 3.55 out of 5.0. Implementation of ISO-9001:2015 Standard based on percentage was at 71% in year 2022. Table 4.1 indicated that Clause 4 is requirement on context of organisation and compliance level was at good compliance. This means WACC, Ajaokuta was good in compliant requirement on understanding organisation and its context, understanding needs and expectations of interested parties; determination of scope of QMS; QMS and its processes for tiles production using ISO-9001:2015 Standard.



Table 1 indicated that Clause 5 is requirement on leadership and compliance level was at good compliance. This means WACC, Ajaokuta was good in compliant requirement on leadership and commitment, quality policy, organizational roles, responsibilities and authorities using ISO-9001:2015 Standard. Clause 6 is requirement on planning of QMS was at good compliance. This means WACC, Ajaokuta was good in compliant requirement on actions to address risks and opportunities, quality objectives and planning to achieve them, planning of changes using ISO-9001:2015 Standard.

Clause 7 is requirement on support and compliance level was at good compliance as in Table 1. This means WACC, Ajaokuta was good in compliant requirement on resources, competence, awareness, communication and documented information using ISO-9001:2015 Standard. Clause 8 is requirement on operation of the company, this was at fair compliance level. This means WACC, Ajaokuta was fair in compliant requirement on operational planning and control, determination of requirements for products and services, design and development of products and services, control of externally provided processes, products and services, production and service provision, release of products and services, control of nonconforming outputs using ISO-9001:2015 Standard.

Clause 9 is requirement on performance evaluation and compliance level was at good compliance as in Table 1. This means WACC, Ajaokuta was good in compliant requirement on monitoring, measurement, analysis and evaluation, internal audit and management review using ISO-9001:2015 Standard. Clause 6 is requirement on planning of QMS was at good compliance. This means WACC, Ajaokuta was good in compliant requirement on actions to address risks and opportunities, quality objectives and planning to achieve them, planning of changes using ISO-9001:2015 Standard.

Clause 10 is requirement on improvement and compliance level was at fair compliance as indicated in Table 1. This means WACC, Ajaokuta was fair in compliant requirement on determination of opportunities for improvement and necessary action to achieve the intended outcome of the Quality management system (General), nonconformity and corrective action and continual improvement using ISO-9001:2015 Standard. However, TQM in WACC using ISO-9001:2015 Standard indicated that WACC, Ajaokuta is ISO-9001:2015 certified company. The audit carried out by this study indicated ISO-9001:2015 was at 71%. Table 4.2 indicated the implementation outcome based on PDCA cycle.

**Table 2: Implementation of ISO-9001:2015 Standard Using PDCA**

Clause	PDCA			
	P	D	C	A
4. Context of organisation	4.00	-	-	-
5. Leadership	3.60	-	-	-
6. Planning of QMS	3.67	-	-	-
7. Support	-	3.60	-	-
8. Operation	-	3.29	-	-
9. Performance Evaluation	-	-	3.67	-
10. Improvement	-	-	-	3.00
Compliance Rating	3.76	3.45	3.67	3.00
Remarks	Good	fair	Good	Fair
Average compliance rating			3.47	Fair
Implementation based on Percentage			69.4%	

The implementation of ISO-9001:2015 Standard using PDCA in WACC, Ajaokuta showed that 3.47 out of 5.0 which was 69.4%. This based on outcome of implementation in the year 2022 as indicated in Table 2. The plan in PDCA involves the context of organisation, leadership and planning of quality management system and compliance rating was good compliance level at 3.76 out of 5.0 as indicated in Table 2. Do in PDCA involves operation and support of WACC, Ajaokuta to produce tiles and compliance rating was fair compliance level at 3.45 out of 5.0 as indicated in Table 2 in Check involves performance evaluation of WACC, Ajaokuta to produce tiles and compliance rating was good compliance level at 3.67 out of 5.0 as indicated in Table 2. However, the Act involves improvement of tiles production and management of tiles production with compliance rating of 3.0 out of 5.0 and this indicated fair compliance level. The business strategy plan by WACC, Ajaokuta was three (3) years



according to Clause 4.1, therefore using linear regression to predict compliance rating of ISO 9001:2015 is stated in Table 3.

**Table 3: ISO 9001:2015 Internal Audit Report on WACC, Ajaokuta**

Year	Compliance Percentage Using ISO-9001:2015	
1(2014)	35.0	using ISO-9001:2008
3 (2016)	51.0	using ISO-9001:2008
6 (2019)	61.5	using ISO-9001:2015
8 (2021)	68.0	using ISO-9001:2015
9 (2022)	71.0	using ISO-9001:2015

The audit report of ISO implementation in WACC, Ajaokuta showed that year 2014 to 2019 quality was audited using ISO 9001:2008 before the upgrade into ISO 9001:2015 version. During ISO 9001:2015 internal audit report on compliance issue of quality management system, audited report on 2019 was at compliance level of 61.5%. There was none quality audit in the year 2020 and however, compliance level of ISO 9001:2015 was at 68%, 71% for the year 2021 and 2022 respectively. The implementation of ISO 9001:2015 took off by year 2019. Therefore, using the audit report of Table 4.3, linear regression of the compliance was:

$$P = 4.75x + 57.33 \quad (1)$$

where:  $P$  = Percentage compliance rating

$x$  = Year after implementation of ISO 9001:2015

Since the business strategy plan by WACC, Ajaokuta was three (3) years the prediction of linear regression was plotted in Figure 1 to illustrate the compliance level.

From Figure 1 it was indicated that from implementation year 2019 of ISO 9001:2015 to year predicted year 2025, there will be compliance level of 62% and 86% respectively. This means significant improvement of 24% in WACC, Ajaokuta towards TQM implementation using ISO 9001:2015.

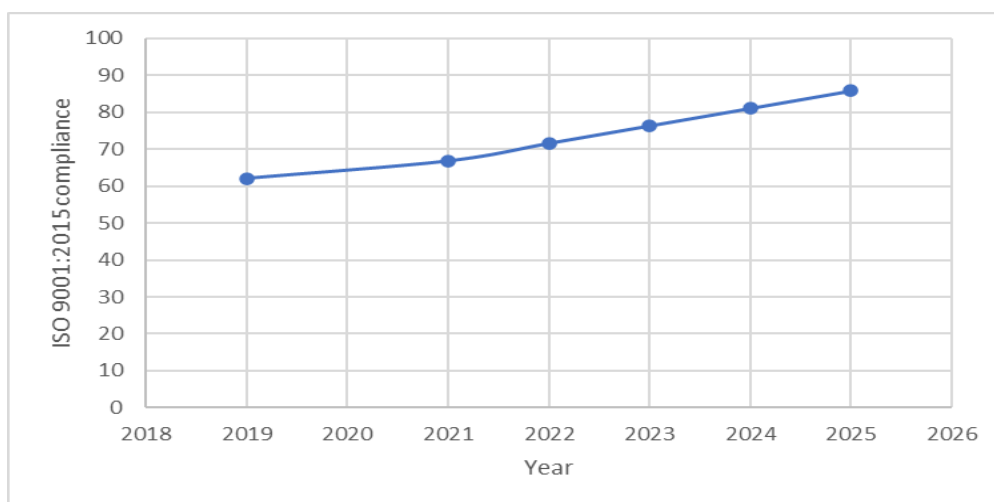


Figure 1: Compliance level of ISO-9001:2015 in WACC, Ajaokuta

## Quality Control of Tiles Production

### P-Chart Analysis

The quality control process of tile production in WACC, Ajaokuta are analysed based on daily productions using P-chart for different six (6) categories of tiles. Tiles production ranges from three (3) thousand (3000) to thirteen thousand (13000) daily. The categories of tiles production in WACC, Ajaokuta are: 40 x 80, 60 x 60, 120 x 60, 40 x 40, 25 x 40, 30 x 40 square centimetres

Table 4 illustrated that Quality control process (QCP) on tiles of 40 x 80 square centimetre which average daily production was 9500 tiles in WACC, Ajaokuta.

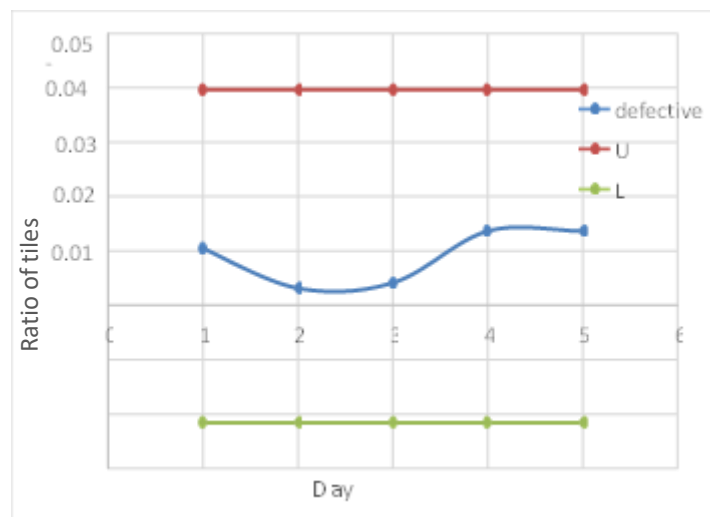
**Table 4: QCP on Tiles of 40 x 80 square centimetres**

Average Daily ( <i>D</i> )	Average defective ( <i>p</i> )	Defective ratio ( <i>r<sub>p</sub></i> )
1	100	0.0105
2	30	0.0032
3	40	0.0042
4	130	0.0137
5	130	0.0137
Average	86	0.0091

QCP analysis of tiles production obtainable from Table 4 and include: Defective ratio,  $r_p = 0.0091$

Daily Standard Deviation = 0.0102, Limit of upper control (*UCL*) = 0.0397 (3 defectives) and average defective tiles per day (86). Limit of lower control (*LCL*) = -0.0215 (0 defective and 2 product of tiles improvement). WACC, Ajaokuta requires working between ranges of 0 and 1 defectives per day for each of batch of 9500 tiles of 40 x 80 square centimetres produced. Figure 2 is the graph showing ratio of defective tiles per daily production of tiles of 40 x 80 square centimetre.

In the graph above the *UCL* indicated approximately 0.04 defective ratio and *LCL* is below 0 margin line. *LCL* of 0.02 indicated the reworking to have improvement on tiles. Table 5 illustrated that Quality control process (QCP) on tiles of 60 x 60 square centimetre in which average daily production was 5364 tiles in WACC, Ajaokuta.



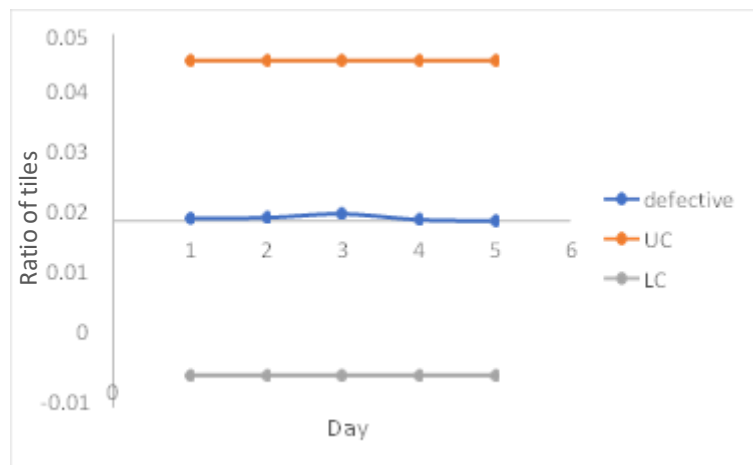
**Figure 2:** Plot of daily defective ratio in 40 x 80 sq. cm tiles

**Table 4.5: QCP on Tiles of 60 x 60 square centimetres**

Average Daily ( <i>D</i> )	Average defective ( <i>p</i> )	Defective ratio ( <i>r<sub>p</sub></i> )
1	4	0.0007
2	5	0.0009
3	10	0.0019
4	2	0.0004
5	0	0.0000
Average	4	0.0008

QCP analysis of tiles production obtainable from Table 5 include: Defective ratio,  $r_p = 0.0008$ , Daily Standard Deviation = 0.0141, Limit of Upper Control (*UCL*) = 0.0431 (0 defectives) and average defective tiles per day (4), Limit of Lower Control (*LCL*) = -0.0415 (0 defective). WACC, Ajaokuta requires working on zero (0) defectives per day for each of batch of 5364 tiles of 60 by 60 square

centimetres produced. Figure 3 is the graph showing ratio of defective tiles per daily production of tiles of 60 x 60 square centimetre.



**Figure 3:** Plot of daily defective ratio in 60 x 60 sq. cm tiles

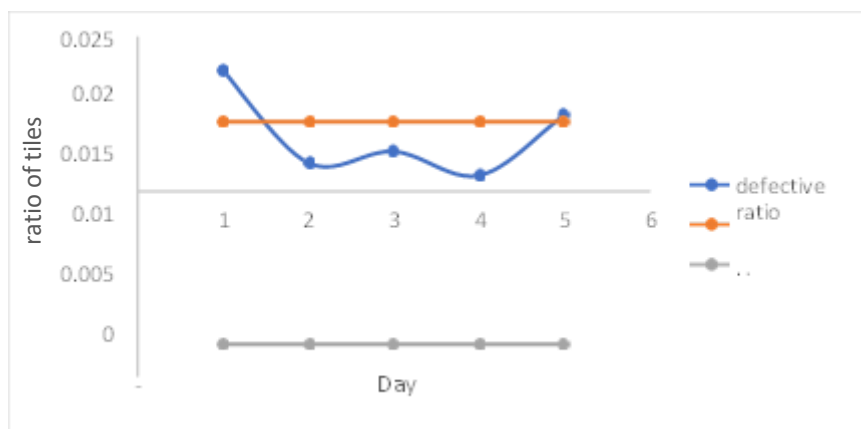
The graph in Figure 4.3 indicated that UCL was approximately 0.045 defective ratio and LCL is below 0 margin line. LCL of 0.04 indicated the reworking to have improvement on tiles production.

Table 6 illustrated that Quality control process (QCP) on tiles of 120 x 60 square centimetre in which average daily production was 7662 tiles in WACC, Ajaokuta.

Table 6: QCP on Tiles of 120 x 60 square centimetres

Average Daily ( <i>D</i> )	Average defective ( <i>p</i> )	Defective ratio ( <i>r<sub>p</sub></i> )
1	150	0.0196
2	35	0.0046
3	50	0.0065
4	20	0.0026
5	95	0.0124
Average	70	0.0091

QCP analysis of tiles production obtainable from Table 4.4 include: Defective ratio,  $r_p = 0.0091$ , Standard Deviation = 0.0113, Limit of Upper Control ( $UCL$ ) = 0.0430 (3 defective) and average defective tiles per day (70). Limit of Lower Control ( $LCL$ ) =  $-0.0248$  (0 defective and 2 product of tiles improvement). WACC, Ajaokuta requires working between ranges of 0 and 3 defectives per day for each of batch of 7662 tiles of 120 x 60 square centimetres produced. Figure 4 is the graph showing ratio of defective tiles per daily production of tiles of 120 x 60 square centimetre.



**Figure 4:** Plot of daily defective ratio in 120 x 60 sq. cm tiles

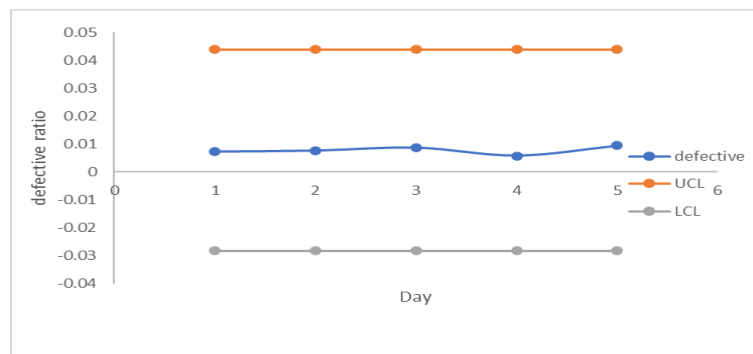
The graph in Figure 4 indicated that UCL was approximately 0.04 defective ratio and LCL is below 0 margin line. LCL of -0.025 indicated the reworking to have improvement on tiles production. Table 7 stated the Quality control process (QCP) on tiles of 40 by 40 square centimetre of Plate IV in which average daily production was 6851 tiles in WACC, Ajaokuta.

**Table 7: QCP on Tiles of 40 x 40 square centimetres**

Average Daily ( <i>D</i> )	Average defective ( <i>p</i> )	Defective ratio ( <i>r<sub>p</sub></i> )
1	50	0.0073
2	53	0.0077
3	60	0.0088
4	40	0.0058
5	65	0.0095
Average	54	0.0078

QCP analysis of tiles production obtainable from Table 4.7 include: Defective ratio,  $r_p = 0.0078$ , Standard Deviation = 0.0120, Limit of Upper Control (*UCL*) = 0.0438 (2 defectives) and average defective tiles per day (54). Limit of Lower Control (*LCL*) = -0.0282 (0 defective and 2 product of tiles improvement). WACC, Ajaokuta requires working between 0 and 2 defectives per day for each of batch of 6851 tiles of 40 x 40 square centimetres produced.

Figure 5 is the graph showing ratio of defective tiles per daily production of tiles of 40 x 40 square centimetre. The graph in Figure 5 indicated that UCL was approximately 0.012 defective ratio and LCL is below 0 margin line. LCL of -0.0282 indicated the reworking to have improvement on tiles production.



**Figure 5: Plot of daily defective ratio in 40 x 40 sq. cm tiles**

Table 8 stated the Quality control process (QCP) on tiles of 30 x 30 square centimetre in which average daily production was 13213 tiles in WACC, Ajaokuta.

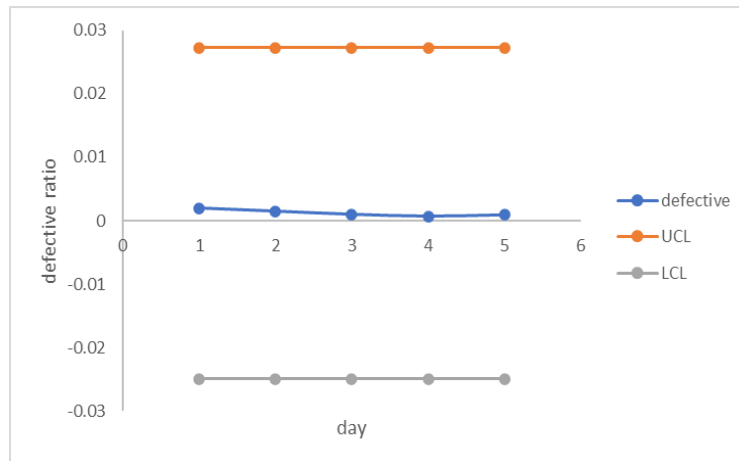
**Table 8: QCP on Tiles of 30 x 40 square centimetres**

Average Daily ( <i>D</i> )	Average defective ( <i>p</i> )	Defective ratio ( <i>r<sub>p</sub></i> )
1	26	0.0020
2	20	0.0015
3	13	0.0010
4	9	0.0007
5	12	0.0009
Average	16	0.0012



QCP analysis of tiles production obtained from Table 8 include: Defective ratio,  $r_p = 0.0012$ , Standard Deviation = 0.0087, Limit of Upper Control ( $UCL$ ) = 0.0273 (0 defectives) and average defective tiles per day (16), Limit of Lower Control ( $LCL$ ) = -0.0249 (0 defective)

WACC, Ajaokuta requires working between 0 defectives per day for each of batch of 13213 tiles of 30 x 40 square centimetres produced. Figure 4.6 is the graph showing ratio of defective tiles per daily production of tiles of 30 x 40 square centimetre.



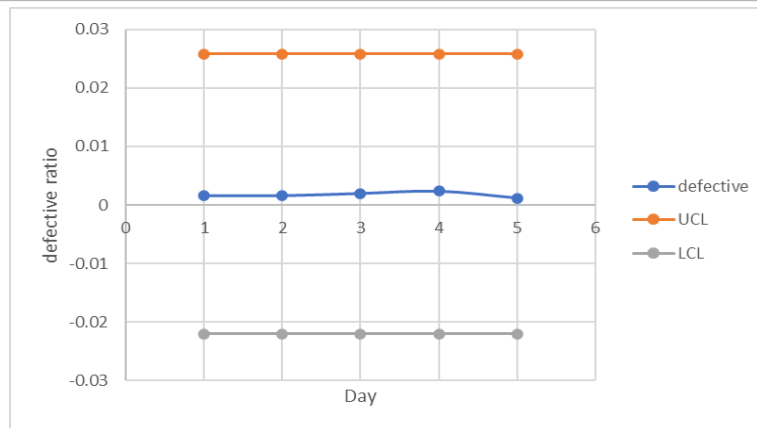
**Figure 6: Plot of daily defective ratio in 30 x 30 sq. cm tiles**

The graph in Figure 6 indicated that UCL was 0.027 defective ratio and LCL is below 0 margin line. LCL of -0.025 indicated the reworking to have improvement on tiles production. Table 4.9 showed the Quality control process (QCP) on tiles of 25 x 40 square centimetre of Plate VI in which average daily production was 12535 tiles in WACC, Ajaokuta.

**Table 9: QCP on Tiles of 25 x 40 square centimetres**

Average Daily ( $D$ )	Average defective ( $p$ )	Defective ratio ( $r_p$ )
1	20	0.0016
2	20	0.0016
3	25	0.0020
4	30	0.0024
5	15	0.0012
Average	28	0.0018

QCP analysis of tiles production obtainable from Table 4.9 include: Defective ratio,  $r_p = 0.0018$ , Standard deviation = 0.0080, Limit of upper control ( $UCL$ ) = 0.0258 (1 defective). Limit of lower control ( $LCL$ ) = -0.0222 (0 defective and 1 tile product improvement). WACC, Ajaokuta requires working between ranges of 0 to 1 defective per day for each of batch of 12535 tiles of 25 x 40 square centimetres produced. Figure 7 is the graph showing ratio of defective tiles per daily production of tiles of 25 x 40 square centimetre.



**Figure 7: Plot of daily defective ratio in 25 x 40 sq. cm tiles**

The graph in Figure 7 indicated that UCL was approximately 0.026 defective ratio and LCL is below 0 margin line. LCL of -0.022 indicated the reworking to have improvement on tiles production. The results from Table 4 – Table 9 indicated that WACC, Ajaokuta needs minimal reworking of the tiles production to be within maximum range of 0 to 3 defectives per daily batch production.

### Operating Characteristics Curve (OCC)

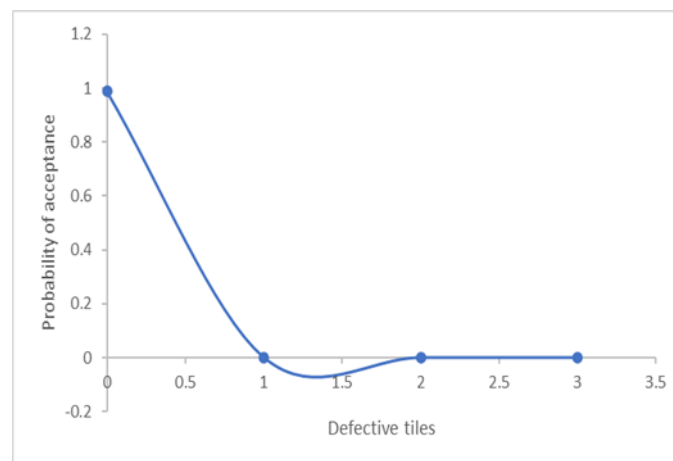
The operation characteristics curve (OCC) is plotted based on percentage of acceptable defective number ( $z$ ) for the whole tiles from Table 4 and Table 9 by using average defective of the tiles ( $p$ ) and average daily tile production.

$$Z = 0.0015$$

The most defective tile profile was maximum of three tiles, therefore,  $n = 3$ .  $P_r = 0.9999$

Zero defective,  $P_0 = 0.9878$ ; One defective,  $P_1 = 0.0001498$ ; Two defectives,  $P_2 = 0.000001$  and Three defectives,  $P_3 = 0.000000$

Figure 8 shows that zero defective tiles will be almost acceptable by the consumers.



**Figure 8: Tiles probability of acceptance by Consumer**

From Figure 8 it was indicated that the maximum allowable acceptable tiles was per day from production and end consumer of the tiles will not accept such products. The graph showed that only zero defective tiles the consumer is willing to accept from WACC, Ajaokuta. To minimize of resources during production, the tiles above one defective will be reworked in the factory.



## Discussion of Results

TQM in WACC using ISO-9001:2015 Standard shown in Table 4.1 indicated implementation level 71% in the year 2022. This means process of quality management that include context of the organization, leadership, planning for the quality management, support, operation, performance evaluation and improvement was in good condition to improve continuous management and production of tiles in WACC, Ajaokuta. The PDCA in Table 2 also indicated 69.4% implementation of total quality management in the company and the company works on three years continual project improvement. The implementation of ISO 9001:2015 took off by year 2019 based on quality audit report and compliance rating, P regression equation was:  $P = 4.75x + 57.33$  in which  $x$  is year after implementation of ISO 9001:2015.

WACC, Ajaokuta needs minimal reworking of the tiles production to be within maximum range of 0 to 3 defectives per daily batch production. The operating characteristic curve (OCC) indicated that only zero defective tiles the consumer is willing to accept from WACC, Ajaokuta.

## Conclusion

The level of TQM implementation in WACC, Ajaokuta has improved quality process on tiles production in the recent. Therefore, the study concludes that TQM in WACC using ISO-9001:2015 Standard indicated implementation level of 71% in the year 2022. It was significant improvement to ensure quality management is in good condition for tiles production in WACC, Ajaokuta. Also, the six major categories of produced tiles in WACC, Ajaokuta had maximum three (3) defectives per daily batch production of three thousand to thirteen thousand for producing 40 x 80, 60 x 60, 120 x 60, 40 x 40, 25 x 40, 30 x 40 sq. cm tiles. WACC, Ajaokuta needs minimal reworking of the tiles production to be within maximum range of 0 to 3 defectives per daily batch production. Operating characteristic curve (OCC) indicated that consumer will accept none defective tiles.

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