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Study of Factors that Sway Industrial Accident Occurrence in the Oil And Gas Industry

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Abstract

Industrial accident occurrence appears to be unending and tends to correlate majorly with human factors and workplace conditions. There are several factors that influences the occurrence of industrial accidents. Unfortunately, many organizations incidentally do not understand explicitly the role each of these factors play individually, collectively and their interaction as they eminently influence accident occurrence. This study is aimed at applying exploratory tool of Kendall's Coefficient of Concordance (KCC) and Principal Component Analysis (PCA) to identify and determine factors that influence industrial accident occurrence the most as well as to ascertain their degree of interaction and interplay among the identified variables and their level of significance. The principal component analysis employed helped in achieving parsimony, trumped four clusters from the identified 38 variables. The four clusters were creatively labeled as work milieu consideration, wing back affairs, behavioral tendencies and work culture. Besides, the KCC results from the ranking of the 15 judges showed that safety culture is the most significant factor. The four factors from the principal component analysis data summarization unveils the principal factors that influences industrial accident causation and provides the frame work and enlightenment needed by managers to whittling down industrial accidents.

1. Introduction

The concern that industrial accident is on the rise in an alarming rate can be attributed majorly to managers of industries not paying due diligence to the associated factors that cause industrial accidents. How their individual, collective roles and interplay amongst factors contributes to this phenomenon are not well grasped.

The size of the problem of industrial accident occurrence is overwhelmingly expanding and the profile of industrial accident is high globally. Several discussants corroborated with this fact and estimated that 2.3 million workers die from work related accidents and diseases; 350,000 results from occupational accidents and around 2 million results from work-related diseases only, while over 474 million people suffer from disease and non-fatal accidents, with the costs of these exceeding US$2.8 trillion, or 4% of gross domestic product [1-7]. The official statistics shows that no fewer than 3,000 industrial accidents take place in Nigeria annually, but the union puts the number at closer to 7,000 due to gross under - reporting and under-recording [8] whereas [9] avers to this, as he posited that the statistics on injury and death experiences in Nigeria represent only the tip of the iceberg. Paraventi [10] stated that the rate of accidents in oil and gas industry is two and half times higher than the construction industries and seven times higher than the general industries. Also, Martinovich [11] mentioned that significant portion of the world's workforce are employed either directly or indirectly by oil and gas industry and that because of its nature and locations, operations risk of injuries in this particular industry are higher as compare to other sectors. The studies of occupational accident had spanned a period of over 100 years which had led to the saving thousands of lives beginning with factory law with focus on monotony, industrial fatigue, accident proneness, to emphasis on work analysis and work selection, motivation and safety training in the 1990s that have broadened to focus on teams, multilevel issues and cultural influence and then safety culture [12]. Many research models have been applied to solve industrial accident occurrence beginning with the scientific approach by [13] and recent trend of predictive analytics by researchers [14, 15]. Be as it may, with the great research models, many researchers and organization have not payed due attention to the in-depth studies of factors associated with industrial accidents in the oil and gas sector as compared to the construction sector, noting their individual, collectively role and their interplay amongst factors, which must be properly understood to avert episodic occurrences. This is central to this study as we ponder if human behavior does correlate with accident causation. Other research work had focus on factors affecting incident rate which include lifestyle, year of experience, population age, groups characteristic, all day shift versus night shift includes [11] and [16-19]. Past research works on factors that influence occupational accident that border more on construction industry includes studies of [20] who identified three types of accident related factors involving work conditions, environmental factor and management actions. Udo et.al [21] mentioned material lifting, tripping on object, and lack of safety measure while handling materials/object. Ahmed [22] identified and ranked causes and effect of accident at construction project based on Relative Importance Index (RII) in Bangladesh. As regards the models applied, it has been widely described in literature [23-26]. The principal component analysis has been widely applied in several fields of human endeavour to analyze data such as administrations, management, chemistry and social sciences and engineering to mention but a few. Besides, in many studies PCA and KCC have been combined to statistically analyses factors that influence the growth and development of Castor shrub and its seeds [27] and also to analyze unique variables that influences the quality and enhance productivity in fibre cement roofing sheet production [28]. It is instructive to note, that from the literature reviewed so far, there are deficit on the use of these conjoint statistical techniques to providing the correlation or interplay amongst factors identified to influence industrial accident causation. The study seeks to enlighten us and ascertain the degree of correlations amongst identified factors that are responsible for industrial accidents in the oil and gas sector.

2.1. Materials and method

Thirty-eight variables were identified from a wide literature survey. The review method identify wide-ranging variables from relevant literature that influence industrial accident occurrence in the oil And gas industry. These variables were used to craft questionnaire that was administered to twenty experts (Judges) in the field of study, where fifteen were retrieved.

The descriptive sample size of the small and medium sized enterprises population employed for this study was obtained by using Eq. (1) to validate an adequate population size for the study.

$$Sample\ \text{Size} = \frac{p(100 - p)z^2}{E^2} \tag{1}$$

where, p is the percentage occurrence of a state or condition

E is the percentage maximum error required

z is the value corresponding to level of confidence required. Taherdoost [29].

2.2. Data analysis

The crafting of the questionnaires was carried out in two different ways. The first set of questionnaires were administered to knowledgeable persons (Judges) who ranked the identified variables that influence industrial accident occurrence in the oil and gas industry.

The Judges were requested to examine the variables (scaled items) and rank them in descending order of importance. The level of concordance or consistency in the ranking of the judges was ascertained using Chi-square (χ^2) test statistic. The statement of hypothesis employed is given in what follows:

H_0 : The ranking of judges are discordant

H_1 : The ranking of the judges are consistent

Decision Rule: if $\chi^2_{cal} > \chi^2_{tab}$, we reject the null hypothesis, H_0.

if $\chi^2_{cal} < \chi^2_{tab}$, we accept the null hypothesis, H_0.

The second set of questionnaires comprises of the thirty-eight (38) critical variables that influence industrial accident occurrence in the oil and gas industry were administered to a hundred and thirty (130) respondents for their expert evaluations of which only a hundred (100) returned their responses. The agreement level of the respondents to the questions scaled with 5-point Rensis Likert's response option shown in Table 2 was evaluated.

Table 2. RensisLikert's 5-Point Response Option

S/NO	RESPONSE OPTION	WEIGHT ASSIGNED
1	Completely-Agree	5
2	Agree	4
3	Undecided	3
4	Disagree	2
5	Completely-Disagree	1

The $(m \text{ x n})$data matrix obtained from the respondents served as input variables that was fed into the Principal Component Analysis model. The major idea of using the principal component analysis (PCA) is to reduce the dimensionality of the data set consisting of a large number of interrelated variables while retaining as much as possible of the variation present in the data set.

3.0.Results and Discussion

3.1 Result of Kendall's coefficient of concordance (KCC)

The Kendall's coefficient of concordance (W) aids us in checking the judge's consistency. Which were calculated using the equation referenced suprain Equation 2 and 3

$$W = \frac{S}{\frac{1}{12}K^2\left(N^3 - N\right)} \quad (2)$$

where, S= sum of variance V_{ij} in the row and column entries of the matrix, K= Number of Judges

= 15 and N= number of variables

$$S = \sum\left(R_j - \frac{\sum R_j}{N}\right)^2 \quad (3)$$

$$\chi^2_{cal} = K\,(N - 1)\,W \quad (4)$$

The Kendall coefficient of concordance (*W*) was obtained as 0.55 using equation 2, and substituting that into chi square (χ^2) equation 4, we have $\chi^2_{cal} = 305.25$
At 5% level of significance, the chi square χ^2 Table value is obtained as 53.36
Since $\chi^2_{cal} = 305.25 > \chi^2_{tab} = 53.36$, we reject the null hypothesis (H_0) and therefore infer that the judges ranking of the 38 scale items were consistent.

Table 2 shows the merit order of sequentiality of the 38 variables as ranked by the fifteen judges and analyzed with Kendall's coefficient of concordance. The $R_{j's}$ determine the ranking order.

Table 2: The Ranking by the Judges by Merit Order of Sequentiality.

S/N	Rj	Variables	S/N	Rj	Variables
1	61	safety culture	**20**	294	overconfidence
2	71	technical know how	**21**	307	Nature of existing workplace
3	107	personal organization	**22**	328	Training Procedures
4	116	Work environment	**23**	329	spilled loads
5	117	poor communication	**24**	329	unsafe equipment
6	136	Mental distractions	**25**	351	Poor Maintenance Culture
7	138	poor supervision	**26**	352	workplace design
8	159	Unsafe procedures	**27**	354	Improper ventilation
9	180	Fatigue	**28**	375	Poor lighting
10	196	Aging of parts	**29**	391	extreme temperature
11	197	Improper materials handling	**30**	392	Hazardous Materials
12	208	Management Negligence	**31**	410	personal protective devices
13	254	unsafe acts	**32**	415	Poor Management
14	274	Vibration	**33**	421	Excessive noise
15	280	Safety devices	**34**	460	Workplace violence
16	289	Sub-System failure	**35**	472	Improper Tool
17	290	Poor work organization	**36**	472	Unsafe Speed
18	292	Unsafe Working condition	**37**	486	Excessive Workload
19	293	Disabled Vehicles	**38**	507	Poor Housekeeping

3.2 Result of Principal Component Analysis

Figure 1 shows the scree plot obtained from the StatistiXL software of the extracted thirty-eight factors. The scree plot displays the eigenvalues on the ordinate axis as against the factors or number of the components in descending order in the abscissa axis. The number of extracted factors generated by the analysis is at a point where the slope of the curve is evidently leveling off (the elbow).

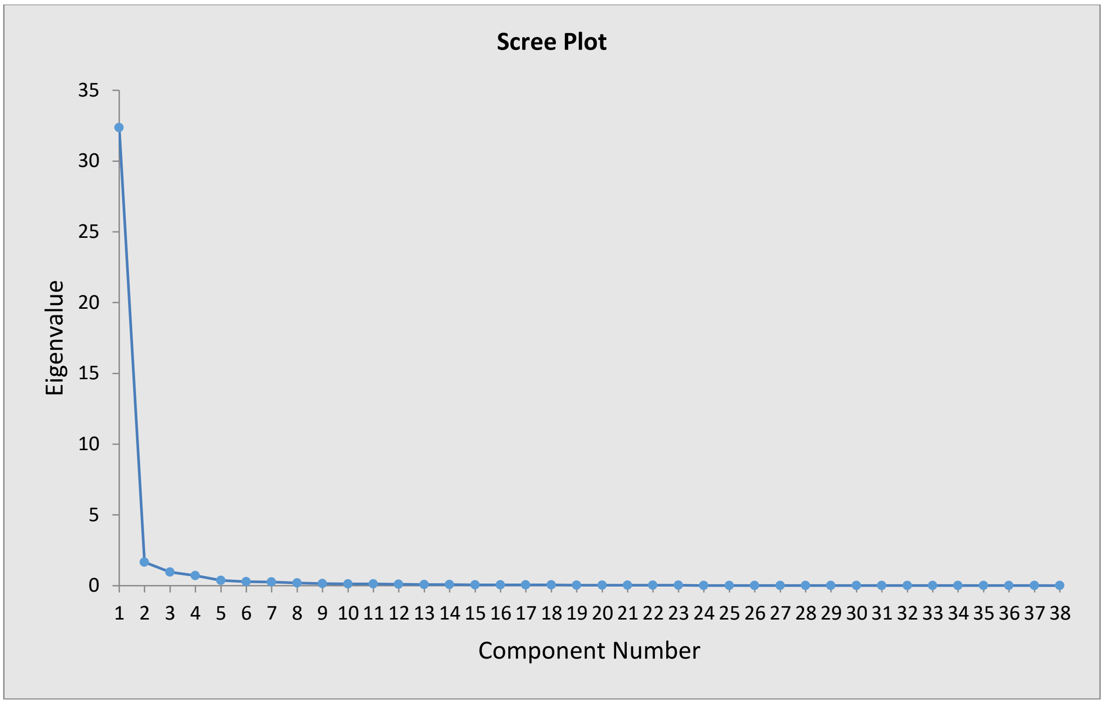

Figure1: Scree Plot

It is evident from the scree plot that at eigenvalue of 1, the curvity tends to flatten out at component number 4, suggesting that four (4) factors extracted are adequate.
Table 3 is the result of the varimax rotated factor loading. The rotation of factor is carried out to simplify their interpretation and creative labeling. Rotation of factor simplifies the row/or column of the factor matrix in a way that the factor loadings become closer to zero (0) or one (1).

Table 3: The Result of the Varimax rotated Factor Loading.

S/N	Variables	Factor 1	Factor 2	Factor 3	Factor 4
1	personal organization	0.461	0.401	0.306	**0.722**
2	poor communication	**0.821**	0.434	0.265	0.132
3	safety culture	0.454	**0.779**	0.260	0.266
4	Excessive noise	**0.552**	0.438	0.505	0.356
5	unsafe acts	0.545	**0.710**	0.279	0.163
6	Mental distractions	0.534	**0.730**	0.265	0.219
7	Management Negligence	**0.809**	0.435	0.275	0.202
8	Aging of parts	0.550	**0.721**	0.250	0.226
9	Hazardous Materials	**0.702**	0.383	0.181	0.490
10	Poor Maintenance Culture	0.489	**0.553**	0.513	0.286
11	Workplace violence	**0.816**	0.398	0.278	0.241
12	Work environment	**0.657**	0.341	0.389	0.407
13	workplace design	0.367	**0.636**	0.482	0.326
14	poor supervision	0.379	**0.804**	0.319	0.263
15	Vibration	0.424	**0.809**	0.317	0.135
16	Nature of existing workplace	**0.793**	0.409	0.276	0.274
17	Poor work organization	**0.616**	0.477	0.567	0.131

18	disabled vehicles	0.413	**0.721**	0.336	0.213
19	Sub-system failure	**0.778**	0.459	0.353	0.134
20	spilled loads	**0.783**	0.483	0.275	0.155
21	excessive workload	**0.756**	0.371	0.386	0.280
22	unsafe working condition	0.507	**0.775**	0.238	0.200
23	Training Procedures	0.430	**0.621**	0.433	0.339
24	Overconfidence	0.578	0.458	**0.609**	0.176
25	unsafe equipment	0.484	**0.754**	0.311	0.145
26	Improper ventilation	**0.720**	0.381	0.246	0.416
27	Poor lighting	0.276	**0.649**	0.547	0.275
28	Poor housekeeping	0.387	**0.745**	0.346	0.218
29	extreme temperature	**0.594**	0.339	0.445	0.440
30	safety devices	0.387	**0.713**	0.407	0.287
31	personal protective devices	0.416	**0.795**	0.307	0.261
32	Poor Management	**0.713**	0.547	0.205	0.241
33	Improper tool	**0.681**	0.405	0.172	0.488
34	Improper materials handling	**0.706**	0.352	0.384	0.333
35	Unsafe procedures	0.363	0.539	**0.608**	0.364
36	technical know how	**0.778**	0.437	0.371	0.139
37	unsafe speed	0.333	0.417	**0.825**	0.138
38	Fatigue	**0.720**	0.566	0.237	0.187

The factor loading was arranged according to their weight i.e. from their highest factor loading to the least factor loading in the four (4) creative label group irrespective of their variable number.

Creative labeling of the three factors:

The factors carefully chosen from the analysis are labelled and given significant interpretation as follow.

Factor 1: Work milieu consideration.

Table 4: Clusters 1(Factor 1): Work Milieu Consideration.

Factor 1: Work milieu consideration		
Variable number	**Variable description**	**Factor loading**
2	Poor Communication	0.821
11	Workplace violence	0.816
7	Management Negligence	0.809
16	Nature of existing workplace	0.793
20	Spilled loads	0.783
19	Sub-system failure	0.778
36	Technical know-how	0.778
21	Excessive load	0.756
26	Improper ventilation	0.720
38	Fatigue	0.720
32	Poor management	0.713
34	Improper material handling	0.706

9	Hazardous materials	0.702
33	Improper tool	0.681
12	Work environment	0.657
17	Poor work organization	0.616
29	Extreme Temperature	0.594
4	Excessive Noise	0.552

According to Table 4 which represents factor one (1) creatively labelled work milieu consideration has variables that describes factor loading of three (3) meritorious and many substantial situation, indicative of the roles of these variables to safe working conditions and consideration. This cluster exposes the fact that poor communication in all ramifications from amongst teams mates to supervisor down the line to management communications is highly responsible for many episodic accident. This follows the claim by [22].

Factor 2: Wing back affairs

Table 5 Clusters 2 (Factor 2): Wing Back Affairs

Factor 2: Wing back affairs		
Variable number	**Variable description**	**Factor loading**
15	Vibration	0.809
14	Poor supervision	0.804
31	Personal protective devices	0.795
3	Safety culture	0.778
22	Unsafe working condition	0.775
25	Unsafe equipment	0.754
28	Poor housekeeping	0.745
6	Mental distraction	0.730
8	Aging of parts	0.721
18	Disabled vehicle	0.721
30	Safety devices	0.713
5	Unsafe Acts	0.710
27	Poor Lighting	0.649
13	Workplace design	0.636
22	Training procedure	0. 621
10	Poor maintenance culture	0.553

introduces a cluster of variables creatively labeled wing back affairs. This regime clustered 16 variables which is exhibiting two meritorious variables (vibration and poor supervision). This suggest that industrial safety experts should pay due attention to these variables by providing defense mechanism for it or apply enough proactive surveillance role to protect human life. Variables in this cluster are highly substantial and middling in their factor loading for example poor supervision and poor maintenance culture. According to [16], driving a safety culture in the oil and gas industry is a major contributor which can be realized by creating a multidisciplinary team that directs this culture. This team indeed understands the needs of the industry and the gaps in skills clearly.

Factor 3: Behavioural Tendencies

Table 6: Clusters 3 (Factor 3): Behavioural Tendencies

Factor 3: Behavioural tendencies		
Variable Number	**Variable Description**	**Factor Loading**
37	Unsafe speed	0.825
24	overconfidence	0.609
35	unsafe procedure	0.608

Factor 3 in Table 6 is creatively labeled behavioral tendencies, an interesting cluster which has one meritorious variable condition, spot lighting unsafe speed as human behavioural tendencies that are responsible for industrial accidents. The rest factor loading can be said to be substantial and necessary for loss event.

Factor 4: Work Culture

Table 7: Clusters 4 (Factor 4): Work Culture

Factor 4: Work culture		
Variable Number	**Variable Description**	**Factor Loading**
1	Personal organization	0.722

This regime clustered a single variable labelled work culture. It shows the peculiarity of the variable (personal organization) in accident causation. Personal organization with a Factor loading value of 0.722 is an essential aspect of work culture, critical to health and safety management. Personal characteristics or personal organizations such as (attitudes, aptitude and motivation) influence accident behavior which relate to that of [16]. The characteristics like personality and motivation serve as a basis for certain behaviour tendencies – such as tendencies to take risks and undesirable attitudes. Three significant factors that influence workers personal organizations are the individual's personal characteristic, the Job - the type of task the individual is assigned to do and if he is competent enough to take on the task and the organizational characteristics (Safety culture or climate and the type of safety leadership style etc.

4.0. Conclusion

In this study, effort was made to analyze several factors that influences the occurrence of industrial accidents in the oil and gas industry. The ranking by the 15 judges in the Kendall's coefficient of concordance analysis shows the merit of sequentiality of the 38 variables identified through survey method. The process of modeling industrial accidents that gave rise to safety culture came first, followed by technical knowhow and personal organization proves the hypothesis that human behaviour correlates to accident causation. This is corroborated by the works of Dejoy and Nielsen [19, 20]. The principal component analysis identified four (4) factors clustered from the 38 variables with factor 3 (Behavioral tendencies) and factor 4 (work culture) singling out a personal organization, all avers to the hypothesis that human behaviour correlates to industrial accident causation. Although, factor 1 in the PCA analysis labelled work mileu consideration falls in the realm of generality that severable variable mix are responsible for loss event and that no single variable is always responsible for accident which supports the combination theory of accident causation. In all count, the study provides enlightenment through their ranked merit order of sequentially and the factor interplay that are necessary for organizations to develop a framework for its safety culture in order to roll back industrial accidents.

References

[1] Krug, E.G., Dahlberg, L.L., Mercy J.A., Zwi, A.B., Lozano, R, (2002) World report on violence and Health Geneva: World Health Organization 2002.

[2] International Labour Organization (2005). Occupational Health & Safety Online, "study:2.2 million people Die world wide of work-Related Accidents, Occupational diseases" retrieved from www.ohsonline.com on September 20, 1-3.

[3] Somavia, J.(2005). Facts on Safety. International Labour Organization.,2. Retrieved from www.ilo.org/communication.

[4] Victor H., and Jose Dimian Perezgonzalez (2007): The Costs and Effects on workplace Accidents, Twenty case studies from Ireland: Health and Studies from Ireland: Health and Safety Authority Research Series 02/2007.

[5] Mock C., Joshipura, M., Quansah, R., Arreda-Risa, C. (2007). Advancing Injury Prevention and Trauma Care in North Arnerica and Globally. Surg Clin North Am. 2007: 87:1-19.

[6] International Labour Organization.(2014) Health at work: a vision for sustainable prevention; XX world congress on safety and health at work 2014; Global forum for Prevention, 24 – 27 August 2014, Frankfurt, Germany, *International Labour office*.

[7] Takala, J. Paivi, H. Kaija, .L.S, Loke, Y.Y, Kaithiresen, M., Tan, W.J., Peggy, H., Caleb, T., Lim, G.K., Samuel, L., and Gan, S.L. (2014). Global Estimates of Burden of Injury and illness at work in 2012. J*ournal of Occupational and Environmental Hygiene vol.11 issue 5(326-337).*

[8] Da Vinci(2010): *Industrial Accidents in Nigeria*. Sunday, 9 May, 2010.

[9] Ezenwa, A.O. (2001).A study of fatal injuries in Nigerian factories. *Occup. Med. Vol. 51. No.8, pp. 485-489.*

[10] Paraventi, C.M. (2014) How to reduce the high fatality rate in oil & gas. Retrieved August 31, 2016, from http://www.ishn.com/articles/99967-how-to-reduce-the-high-fatality-rate-in-oil-gas.

[11] Martinovich, T. (2013). Factors Influencing the Incident Rates of injuries and accidents among Seafarers and rig workers providing support to WA offshore oil and gas Industry. Doctorate and Master's Thesis Edith Cowan University.

[12] Hofmann, D.A., Burke, M.J and Zohar Dov (2017). 100 Years of Occupational Safety Research: From Basic Protections and Work analysis to a Multilevel View of Workplace safety and Risk. *Journal of Applied Psychology*, Vol.102, No.3, 375 -388.

[13] Heinrich, H.W(1931). Industrial accident Prevention: A scientific Approach., New York 1st ed McGraw- Hill, 1931

[14] Predictive Analytics in Workplace Safety (2012): Four 'Safety Truths' that Reduce Workplace Injuries. Predictive Solution an industrial scientific company

[15] Kelly, B. (2014). What are you Using Your Safety Data For*? Published May 2nd,. www.talentclick.com/safety*

[16] Alkhaldi, M., Pathirage, C. and Kulatunga, U. (2017). The Role of Human Error in Accidents within Oil and Gas Industry in Bahrain. School of the Built Environment, University of Salford, Salford, M5 4WT, UK.

[17] Mahammad, f. I., Soltanzadeh, A., Moghimbeigi, A., Akbarzadeh, M. (2013). Factors affecting occupational accidents in the construction industry (2009-2013). *Journal of occupational Health and Epidemiology April 2014.*

[18] Tsang, Y.T. Fung, I.W.H., Tam, V. W.Y, Sing, C.P, & Lu, C.T. (2017). Development of Accident Modelling in the Hong Kong Construction Industry, *International Journal of Construction Management, 17(2),* 124-131.

[19] Dejoy, D.M (2005). Behaviour changes Versus Culture Changes Divergent approaches to managing Workplace Safety. *Safety Science,* 43, pp.105-129.

[20] Nielson, K..J. (2013). Improving Safety Culture through the Health and Safety Organization: A Case study. *Journal of safety Research* Vol. 48.february 2014,pp 7-17

[21] Udo, U.E., Usip, E.E., and Asuquo, C.F. (2016). Effect of Lack of Adequate Attention to Safety Measures on Construction Sites in Akwa Ibom State. *Nigeria Journal of Earth Sciences and Geotechnical Engineering*. 6(1), 131-121.

[22] Ahmed. S, (2019) Courses and Effect of Accident at Construction Site: A Study for the Construction Industry in Bangladesh. *International Journal of Sustainable Construction Engineering and Technology* Vol. 10 No. 2, 18-40.

[23] Jolliffe, I. T. (2002). Principal Component Analysis, 2nd ed. Springer Library of Congress cataloging-in-publication Data.

[24] Kothari, C.R (2004). Research methodology methods and Techniques. (Second Revised edition) New Age International Publishers.

[25] Legendre, P. (2005). Species Association: The Kendal Coefficient of Concordance Revisited, Journal of Agriculture, Biological and Environmental Statistics, vol. 10, No. 2 pp226 – 245

[26] Baran, A.J and Newman, S.M (2017). On the Application of Principal component analysis to the Calculation of Bulk Integral Optical properties for Radiation Parameterizations in climate models. *Optic Letters*, Vol.42. Issue 5, pp.983-986

[27] Omotehinse, S.A and Igboanugo, A.C (2017).Statistical Analysis of Factors that influence the Growth and Development of Castor Shrub and its Seed. *International conference Nigeria institute of Industrial Engineers Ibadan 2017. Theme: Engineering Entrepreneurship for National development*

[28] Igboanugo, A.C., Bello, K.A and Chiejiene, C.M (2016). A factorial study of fibre cement roofing sheet manufacturing.. *Journal of Multidisciplinary Engineering Science and Technology(JMEST)*.Vol.3 Issue2, pp.3885-3892

[29] Taherdoost, H. (2017) Determining Sample Size; How to Calculate Survey Sample Size. International Journal of Economics and Management Systems, Volume 2, 237-239.