

# GLOBAL JOURNAL

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## Mechanical & Mechanics Engineering

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Highlights

Profile of a Post Doctoral Research

Texture based Animal Segmentation

Discovering Thoughts, Inventing Future

VOLUME 23

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MECHANICAL AND MECHANICS ENGINEERING

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## Texture based Animal Segmentation in Aerial Videos

By Rishaad Abdoola, Yunfei Fang, Shengzhi Du, Paul Bartels  
& Christiaan Oosthuizen

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**Abstract-** Animal detection in aerial videos is a challenging problem due to the complex nature of the scenes involved as well as the natural ability of the animals to camouflage their environment. To assist with the detection and classification of animals for the purpose of nature conservation management, texture analysis is applied to aerial videos of wildlife scenes to segment the environment from the animals. To perform automatic wildlife surveying and animal monitoring, it is proposed to use GLCM texture segmentation to reduce the search area for animals in the aerial videos. Using the texture in the scene, the issues of a moving background and unpredictable state of the animal are avoided. The method presented is well suited to implementation on a UAV as it is easily parallelizable.

**Keywords:** image segmentation, GLCM, texture analysis, animal tracking, animal segmentation.

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# Texture based Animal Segmentation in Aerial Videos

Rishaad Abdoola <sup>α</sup>, Yunfei Fang <sup>σ</sup>, Shengzhi Du <sup>ρ</sup>, Paul Bartels <sup>ω</sup> & Christiaan Oosthuizen <sup>¥</sup>

**Abstract-** Animal detection in aerial videos is a challenging problem due to the complex nature of the scenes involved as well as the natural ability of the animals to camouflage their environment. To assist with the detection and classification of animals for the purpose of nature conservation management, texture analysis is applied to aerial videos of wildlife scenes to segment the environment from the animals. To perform automatic wildlife surveying and animal monitoring, it is proposed to use GLCM texture segmentation to reduce the search area for animals in the aerial videos. Using the texture in the scene, the issues of a moving background and unpredictable state of the animal are avoided. The method presented is well suited to implementation on a UAV as it is easily parallelizable.

**Keywords:** image segmentation, GLCM, texture analysis, animal tracking, animal segmentation.

## 1. INTRODUCTION

Nature conservation and wildlife management depends on accurate and reliable animal census data over time. Such surveys are often conducted on the ground by conservation workers or from the air utilizing rotary or fixed wing aircraft. The former requires a large amount of manpower while the latter is too expensive for the majority of nature reserves and wildlife ranches. Performing census in this manner, means that data cannot be collected regularly, reducing the effectiveness of nature conservation management. An alternative, more efficient and effective method for wildlife data collection is required.

The development and reduction in costs of Unmanned Aerial Vehicles (UAVs) have made them affordable and easy to operate. UAV's have become popular in aerial surveillance and data collection. Applying UAV's to wildlife surveying seems sensible but offers a number of challenges. Since there are currently no well-developed existing systems, the problem lies in the system structure and analysis of methods of the data collected by the UAV.

In a wildlife scenario, a UAV is launched to collect data of regions where animals are active. A programmed FPGA kit is to be mounted on the UAV,

serving as an onboard analyzing system, to detect animals quickly and automatically. Frames containing animals will be labelled and recorded for further analysis. Methods with improved accuracy will be applied to locate and track animals in these frames to reveal herd patterns or location information of various species. For each task, methods will be evaluated to minimize error, and to reduce computational load due to the constraints of the UAV.

This research aims to add to a larger project undertaking involving the building of a UAV based wildlife census system to provide an autonomous solution to a series of challenges in wildlife conservation. Tracking animals in the wild is one of the most complex contexts as it deals with tracking multiple objects from a moving camera with a dynamic, cluttered background. The main challenges in animal tracking can be summarized as follows:

- *Aerial perspective:* Appearance of the animals and objects would be totally different from the ground perspective.
- *Moving camera:* Abundant work has been done on object detection in stationary scenes. A moving camera indicates the pixel values of the background changes over time negating most background subtraction methods for detection.
- *Dynamic background:* A dynamic background is similar to a moving background in which the pixel value changes but obeys a regular pattern. Examples of a dynamic background include noise, changing illumination, waves on water, trees waving in the wind, shadows, smoke, fire flames, etc.
- *Unpredictable state of the animal:* Successfully applied tracking systems usually assume that the object is always in motion; some even assume the orientation, velocity, or acceleration of the motion. But the state of the animals cannot be predicted in the wild.
- *Protective coloration:* Animals' skin tends to exhibit similar color and texture to the background, which will reduce the effectiveness of methods that are sensitive to color.

In this paper we focus on reducing the search area for the animal in the scene by using both the texture of the environment and the animal. Using the texture in the scene, the issues of a moving background and unpredictable state of the animal are avoided.

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## II. RELATED WORK

Sirmacek and Wegmann [1] extracted local features to detect focus regions in aerial images and then applied a mean-shift segmentation algorithm to detect and locate animals in the image. Many aerial images were used to test and evaluate the algorithm. This method was aimed at segmentation in single images and did not address the topic of detection and tracking in videos. Gemert and Verschoor [2] investigated the current detection methods designed for human centered objects and evaluated three lightweight detection and tracking algorithms suitable for onboard implementation. The datasets for experimentation were videos of cows recorded on a farm, which has a much less sophisticated environment and is not representative of the types of scenes we encounter in the wild. Animal counting is based on detection, and KLT (Lucas-Kanade-Tomasi) tracker for salient points was used which is more stable to enumerate. Counting results showed a very low precision.

In conventional outdoor applications like pedestrian surveillance and traffic monitoring, a dynamic background is obviously inevitable. A common idea is to build a background model based on the statistical distribution of the pixel color value and distinguish the pixels that belong to the foreground. In [3] a Gaussian mixture model (GMM) was used to model each pixel and utilize an on-line approximation to update the model. The background pixels were classified based on whether the Gaussian distribution represents it effectively or not. In [4], the background was modelled by an Autoregressive Moving Average Model (ARMA), followed by the application of a Kalman Filter to estimate the state of the object in successive frames. Implementations were done on single objects in outdoor scenes. C. Ridder, O. Munkelt, and H. Kirchner [5] also

proposed a Kalman filtering based algorithm to form a real-time tracker that can deal with illumination changes and repetitive motions of the background. The system was successfully applied in human body tracking in a real-world scene. All of these algorithms are focused on scenes with stationary cameras and constant background.

To deal with moving object detection with moving cameras, a typical method is the extension of background subtraction. In [6], the authors used registration methods to model the background in subsequent frames. Backgrounds from different frames were then stitched together into a planar mosaic. The moving objects were then segmented in a similar way to the stationary camera case. The method was implemented in indoor scenes to detect human bodies. In [7] the authors extended such mosaic algorithms to the outdoor scene to monitor vehicles on highways from an aerial perspective. Motion-based approaches [8] were also proposed to detect and track moving objects with moving cameras. In [9], the authors proposed to use a GMM to model the motion changes (optical flow value changes) for background subtraction. Pixel value modeling that is usually used in a stationary camera scene is replaced by motion vectors, since it is assumed that the motion of the background pixels follows some pattern like that of the pixel values in a stationary camera scene. This is also orientated to vehicle detection and tracking.

## III. PROPOSED METHOD

The proposed method is to use the GLCM of both a texture of the background and the animal species and then determine the intersection of the two to generate the final result.

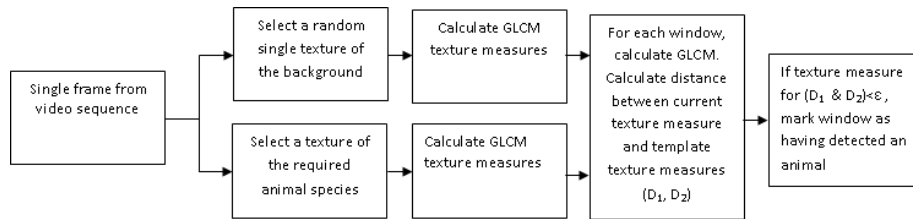


Fig. 1: Flow chart of algorithm

### a) Gray Level Co-Occurrence Matrix

The grey Level Co-occurrence Matrix (GLCM) is defined over an image to be the distribution of co-occurring values at a given offset. It measures how often different combinations of pixel brightness values or grey levels occur in an image. GLCM is based on the relationship between two pixels. The distance (in terms of pixel) between a reference pixel and its neighbor defines the offset. The offset will be equal to one for this paper. Larger offsets could be used, resulting in a smaller number of pixel combinations. The neighboring

pixel can take different positions with respect to the reference pixel; it can be next to (left, right), above or on the diagonal with respect to the reference pixel. The neighbor pixel will be selected to be to the right of the reference pixel for this paper. To reduce the size of the GLCM and increase the occupancy level of the matrix, the quantization level is set to 16.

### b) Texture Measures from the GLCM

Texture calculations performed on the GLCM are of “second order”. First order texture measures are



calculated from the original image values and they do not consider spatial relationships. Second order measures consider the relationship between groups of two neighbor pixels in the original image. Texture calculations are weighted averages of the normalized GLCM cell contents. Once a texture calculation is performed for one specific GLCM corresponding to a particular position of the window, the window moves to the next position and the same procedure is repeated. Texture measures can be classified into different categories depending on the type of information they provide. Certain measures are based on the contrast information while others are based on the orderliness and the descriptive statistics of the GLCM texture measures. The following describes only the texture measures used in this paper.

i. *Contrast*

$$Contrast = \sum_i \sum_j |i - j|^2 P(i, j) \quad (1)$$

where  $P(i, j)$  is the probability at row  $i$  and column  $j$  of the GLCM.

ii. *Energy*

$$Energy = \sum_i \sum_j P(i, j)^2 \quad (2)$$

where  $P(i, j)$  is the probability at row  $i$  and column  $j$  of the GLCM. Energy will be equal to 1 for a constant image.

iii. *Correlation*

$$Correlation = \sum_i \sum_j \frac{(i - \mu_i)(j - \mu_j)P(i, j)}{\sigma_i \sigma_j} \quad (3)$$

where  $\mu_i, \mu_j, \sigma_i, \sigma_j$  are the means and standard deviations respectively. Correlation is a measure of the gray level linear dependence between the pixels at the specified positions relative to each other. A value of 0 implies that the pattern is uncorrelated, 1 implies perfect correlation and -1 implies that the spatial set exhibits a dissimilar, deterministic structure.

iv. *Homogeneity*

$$Correlation = \sum_i \sum_j \frac{P(i, j)}{1 + |i - j|} \quad (4)$$

Homogeneity measures the closeness of the distribution of elements in the GLCM to the GLCM diagonal. In the homogeneity measure, the weight values are the inverses of the contrast weight values. As we move further away from the diagonal, the weights decreases quadratically.

c) *Background Detection using GLCM*

The background is segmented by selecting a single texture feature of 60x60 pixels of each scene tested. The background texture feature was manually selected to demonstrate the method. A single texture was selected to show the viability that using a single texture can still provide good results. In the future work, a number of textures of background scenes will be selected and trained offline and used to classify any scene or multiple random textures will be selected during the UAV flight and the average of the textures will be used as the texture template.



Fig. 2: Two typical scenes (Zebra [Equus quagga] scene on the left and Blesbok [Damaliscus pygargus phillipsi] scene on the right) of the environments of the datasets and the respective textures selected

A number of texture measures were tested but the ones that appeared to give the best results for the background were energy, contrast, correlation and

homogeneity. The distance measure for the comparison to the image window was calculated as

$$( | Energy_{template} - Energy_{window} | < \varepsilon_1 ) \wedge ( | Corr_{template} - Corr_{window} | < \varepsilon_2 ) \wedge ( | Hom_{template} - Hom_{window} | < \varepsilon_3 ) \wedge ( | Cont_{template} - Cont_{window} | < \varepsilon_4 ) \quad (5)$$

Figure 3 shows an example of the original output frame of the zebra video sequence and the frame after background estimation. While some artefacts or false detections exist, these will be reduced in the

following steps. It can also be seen that parts of the scene in the top of the image were not segmented as well as some of the trees. This will be solved once more scene features are added and trained but it will also be

seen in the following steps that this undetected background scenes will not severely affect the final outcome. None of the zebras in the scene were selected

as being part of the background. Figure 4 shows similar results but for the blesbok output sequence.

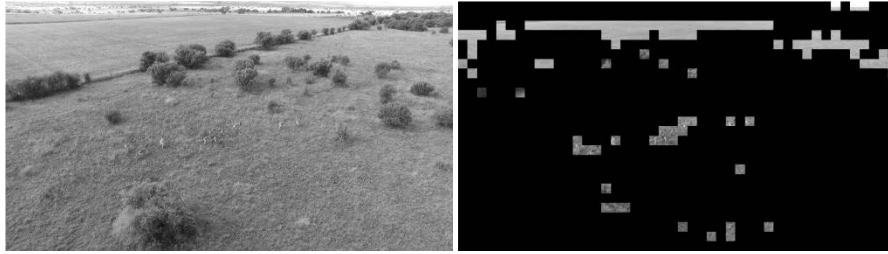


Fig. 3: (Left) Zebra scene frame and (Right) Background area segmented out

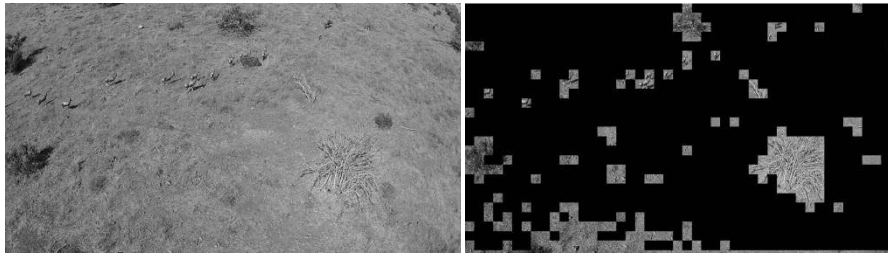


Fig. 4: (Left) Blesbok scene frame and (Right) Background area segmented out

#### d) Animal Detection using GLCM

The animals are detected by using the 60x60 texture pattern selected for the zebra and 60x40 for the blesbok. The distance measure is calculated in the same manner as (5). The texture patterns selected for the zebra and blesbok are shown in figure 5.

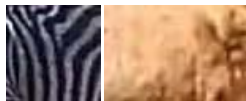


Fig. 5: (Left) Zebra texture and (Right) Blesbok texture

Figure 6 shows the foreground texture segmentation applied to frames from the data-set. It can be seen that all the zebras have been selected as being part of the fore-ground but there remains a lot of artefacts. In the left image it can be seen that a single blesbok has not been correctly segmented. The artefacts could be reduced by adjusting the parameters but this causes some of the zebras to not be selected. Since the aim is to reduce the search area, it is imperative that as many of the zebras and blesbok as possible are selected at this stage.



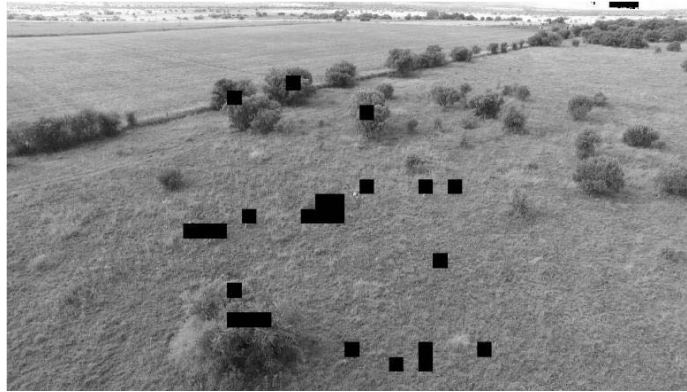
Fig. 6: (Left) the zebras are detected using the zebra texture and (right) Blesbok detected using blesbok texture

#### e) Intersection of the Background and Animal Detection to Improve Results

The intersection of the two results, the foreground detection of the animals and the background detection of the environment, is now performed to reduce the number of artefacts present in the images. Figure 8 and 10 shows the final result in which the inverse of the background segmentation is intersected with the foreground segmentation to provide the final output. While a few artefacts still remain, the animals have been largely segmented from the background.



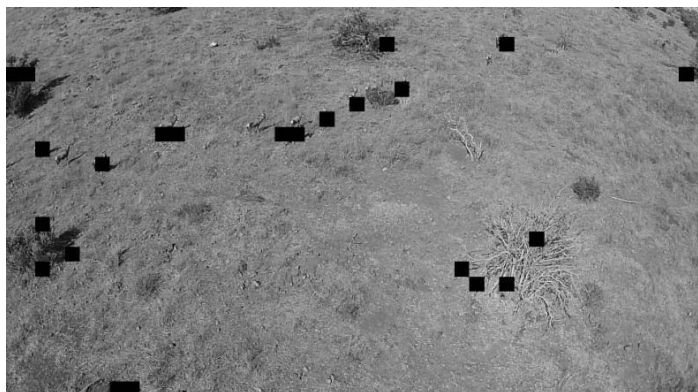
*Fig. 7:* Single frame from zebra scene video



*Fig. 8:* Final segmented image of figure 7



*Fig. 9:* Single frame from blesbok scene video



*Fig. 10:* Final segmented image of figure 9



#### IV. RESULTS

The results were collected from three video scenes. The first video scene contains zebras and the second and third video scenes contain blesbok (one from a high altitude and another from a lower altitude).

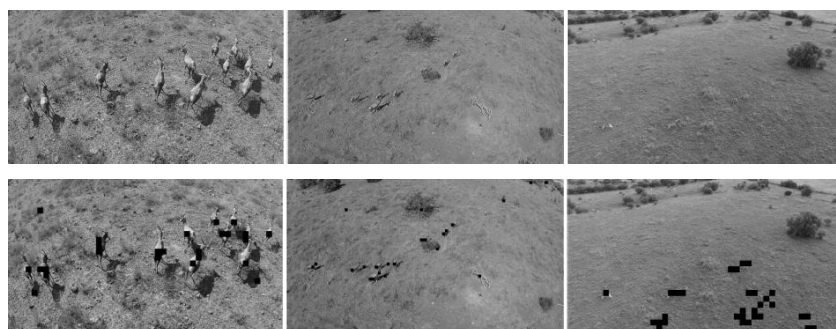


Fig. 11: (Top) Various frames from the datasets and (bottom) the final results

Table 1: Results of segmentation

| Species       | Total Frames | Ground Truth | Positive detection of animals | False negative |
|---------------|--------------|--------------|-------------------------------|----------------|
| Zebra         | 400          | 3100         | 76%                           | 23%            |
| Blesbok(near) | 200          | 2600         | 84%                           | 16%            |
| Blesbok (Far) | 400          | 5200         | 81%                           | 19%            |

#### V. CONCLUSION AND FURTHER WORK

A GLCM texture segmentation method was presented to segment animals from the background in a natural environment to reduce the search area for animals in the aerial videos. The method presented has shown promising initial results when tested on datasets collected in real South African environment. The method presented is well suited to implementation on a UAV as it is easily parallelizable algorithmically. Future work will involve using Bayesian classifier to train multiple scenes of background textures such as rocks, trees and various types of surfaces encountered. Various animal textures will also be trained and video sequences will be classified into two categories, animal or background. Once an animal is detected it will be tracked to eliminate the need for further detections in frames. Real-time capabilities will be investigated.

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The false negative is more important for the project as the false positives will be reduced during further detection and identification as well as the training of the textures. The objective was to segment areas of the image containing animals and not to detect animals.

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# The Influence of Mono- and Polyreinforcement on the Tribological Properties of Polymer Composites based on Organic Silicon Binder

By Yeromenko Olexander & Tomina Anna-Mariia

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**Abstract-** The article examines the effect of discrete basalt fiber and hybrid mixture on the tribotechnical properties of the organosilicon binder. It was established that basalt plastic with a fiber content of 40-50 mass.% is characterized by the highest wear resistance index, but by high values of the coefficient of friction and temperature in the contact zone. The high indicators of the latter can be explained by the friction of the basalt fiber. Hidden crystal graphite was added to the composition of basalt plastic to reduce the coefficient of friction and temperature in the contact zone. As a result of the conducted research, it was established that the best complex of tribological properties is characterized by a hybrid composite containing 35 mass.% of basalt fiber and 35 mass.% of hidden crystalline graphite.

**Keywords:** basalt fiber, graphite, coefficient of friction, intensity of linear wear, antifriction aggregate, rolling bearing.

**GJRE-A Classification:** TA404.2, TA418.9.C6



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# The Influence of Mono- and Polyreinforcement on the Tribological Properties of Polymer Composites based on Organic Silicon Binder

Yeromenko Olexander <sup>α</sup> & Tomina Anna-Mariia <sup>σ</sup>

**Abstract-** The article examines the effect of discrete basalt fiber and hybrid mixture on the tribotechnical properties of the organosilicon binder. It was established that basalt plastic with a fiber content of 40-50 mass.% is characterized by the highest wear resistance index, but by high values of the coefficient of friction and temperature in the contact zone. The high indicators of the latter can be explained by the friction of the basalt fiber. Hidden crystal graphite was added to the composition of basalt plastic to reduce the coefficient of friction and temperature in the contact zone. As a result of the conducted research, it was established that the best complex of tribological properties is characterized by a hybrid composite containing 35 mass.% of basalt fiber and 35 mass.% of hidden crystalline graphite.

**Keywords:** basalt fiber, graphite, coefficient of friction, intensity of linear wear, antifriction aggregate, rolling bearing.

## I. INTRODUCTION

The reliability and durability of metallurgical, food, and textile equipment directly depends on the trouble-free and efficient operation of sliding bearings [1]. The metal base of the bearing ensures its rigidity and strength, and anti-friction filler (AFF) ensures its resistance to wear and corrosion, stability of properties during operation. The choice of AFF depends on the operating conditions of tribological units equipped with rolling bearings. One of the technological methods of increasing the wear resistance of bearings is the use of polymer composite materials (PCMs) as AFF. Rolling bearings modified by AFF are characterized by stable operation under the influence of high temperatures, moisture, abrasive dust, acids and alkalis, resistance to shock loads. Another important advantage of using AFFs made of PCMs is the stability of operation in conditions without additional lubrication. Today, hybrid (polyreinforced) PCMs, containing a mixture of fibrous and powder fillers as a filler, are being actively used. It is known from literary sources [2] that the use of fibrous fillers provides strength and resistance to PCMs loads, and powder fillers are able to provide the effect of "self-lubrication" [3,4]. Thus, the use of rolling bearings containing hybrid PCMs as an AFF made it possible to increase the durability of bearing assemblies more than

5 times, compared to open and sealed rolling bearings which are lubricated by plate lubricators.

Taking into account the above, the development of a new wear-resistant AFF is an urgent task of modern materials science.

## II. RESEARCH OBJECTS AND METHODS

Organosilicon rubber (OR) was chosen as a polymer matrix for the creation of AFF.

We used the followings to create basalt plastics (BP) and hybrid PCMs based on organosilicon polymer:

- discrete basalt fiber (BF) with an elementary fiber diameter of 13 μm (JSC "NDI SV", Ukraine);
- hidden crystalline graphite which is characterized by an unfinished texture, often contains an admixture of finely dispersed carbonaceous matter in its composition [5, 6];

Preparation of composites based on organosilicon polymer containing mixtures was carried out in a horizontal mixer followed by thermoreactive crosslinking of the polymer matrix at a temperature of 393 K for 30 minutes. The tribotechnical properties of the composites according to the "disk-pad" scheme were studied on the SMC-2 friction machine, under conditions of friction without lubrication, at a load of 1,0 MPa, and a sliding speed of 1,0 m/s. The counterbody is steel 45 (45-48 HRC,  $R_a=0,32 \mu\text{m}$ ) [7]. The temperature in the contact zone was determined using a thermocouple at a distance of 3 mm from the friction surface.

## III. RESEARCH RESULTS

It can be seen from table 1 that BP containing 40-50 mass.% of discrete basalt fibers are characterized by high indicators of wear resistance.

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*Table 1:* Tribotechnical properties of basalt plastics

| Indicator                                     | Fiber content, mass.% |      |      |       |
|---|-----------------------|------|------|-------|
|   | 40*                   | 50*  | 60** | 70*** |
| Intensity of linear wear, $I_h \cdot 10^{-6}$ | 3,38                  | 2,16 | 6,61 | 7,36  |
| Temperature in the contact zone, K            | 443                   | 485  | 386  | 378   |

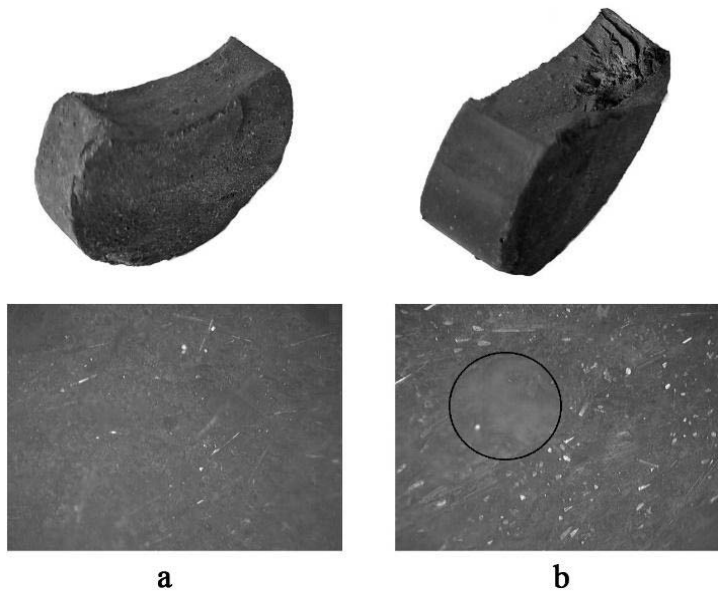
where \* – friction path is 1000 m;

\*\* – friction path is 480 m;

\*\*\* – friction path is 370 m.

There is a sharp drop in wear resistance With a further increase in the BF content in the composite up to 70 mass.%. This can be explained by the fact that the degree of uniformity of polymer distribution on the surface of the fiber has significantly decreased, as a result, the structure of the composite contains a significant number of pores and voids. This conclusion is confirmed by the study of the friction surface of BP

samples after the tests. Comparing the friction surfaces of BP (see Fig. 1), it can be seen that the composite containing 70 (b) mass.% of BF undergoes significant morphological changes compared to the content of 50 mass.%. you can observe zones of BF precipitation (circled) due to insufficient adhesion between BF and the organosilicon matrix on the friction surface of basalt plastic.



*Figure 1:* Basalt plastics after friction, containing 50 (a) and 70 (b) mass.% of basalt fiber

It is interesting to note that the coefficient of friction of the developed BPs reaches about 0,9. It can be explained by the fact that BPs belong to frictional fillers, as a result, they increase the friction forces in the contact zone between the steel counterbody and the test sample. This conclusion is confirmed by measuring the temperature in the contact zone between the BP and the steel counterbody. In the course of the experiment, it was found that its value varies between 443-485 K (friction path is 1000 m). This can be explained by the fact that BF is characterized by a low thermal conductivity (0,064–0,096 W/m·K), as a result of which the removal of temperature from the contact zone is insufficient [7].

Hidden crystal graphite was added to the BP to reduce the coefficient of friction and temperature in the contact zone,. It was established that hybrid PCMs are

superior to basalt plastics 72-168 times in terms of the intensity of linear wear (see Table 2). This is due to the fact that the hidden crystalline graphite performs the function of a solid lubricating material, and in the process of friction, its finely dispersed wear products are transferred to the surface of the steel counterbody and form a protective (anti-friction) layer on it (see Fig. 2). The latter is characterized by high adhesion to the metal counterbody and low resistance to shear, as a result of which there is a decrease in frictional forces between the sample and the counterbody. Thus, the coefficient of friction of hybrid PCMs friction is 0,3-0,5, which is 1,8-3 times less compared to BP. The confirmation of what has been said is a decrease in temperature in the contact zone between the sample and the counterbody by 100 degrees.

*Table 2:* Composition and wear resistance of hybrid polymer composite materials

| № | Composites content, mass. % |    |     | Intensity of linear wear, $I_h \cdot 10^{-8}$ | Temperature in the contact zone, K |
|---|-----------------------------|----|-----|---|------------------------------------|
|   | OR                          | BF | HCG |   |                                    |
| 1 | 60                          | 20 | 20  | 80,00   | 358                                |
| 2 | 50                          | 25 | 25  | 15,70   | 353                                |
| 3 | 40                          | 30 | 30  | 4,80  | 350                                |
| 4 | 30                          | 35 | 35  | 4,63  | 339                                |



*Figure 2:* The anti-friction layer formed on the surface of the counterbody in the process of friction of the sample №4 of the hybrid composite

In addition, other possible factors that affect the improvement of the tribological properties of PCMs are the thermal properties of the filler. It is known from literary sources [8] that graphite is characterized by a high (from 278.4 to 2435 W/(m·K)) coefficient of thermal conductivity, close to a copper one. According to the theory [9], high indicators of thermal conductivity contribute to the removal of heat from the friction zone and, as a result, the localization of high temperature in the contact zone of tribological pairs disappears, accordingly, the probability of the development of processes of thermomechanical destruction in the volume of the part, which leads to its catastrophic wear, decreases, as a result, reducing the reliability and stability of work [10].



*Figure 3:* Rolling bearing № 62306 with AFF, sample № 4

The obtained results of laboratory studies allowed to proceed to production tests. Food industry equipment includes a significant number of heat treatment and baking processes, which in turn requires constant lubrication of rolling bearings. The hybrid PCM № 4 was used in the modification of rolling bearings (№ 62306, Fig. 3) of AFF, which are used for the tunnel oven for baking confectionery products and equipment for roasting peanuts. The operating temperature reaches 473–523 K. The results of production tests confirmed the feasibility of using the developed PCM as an AFF.

#### IV. CONCLUSION

As a result of the conducted tribological studies, it was established that polyreinforced PCM, which contains 35 mass.% of BF and 35 mass.% of hidden crystal graphite, is characterized by the best set of tribological properties. The fiber provides the composite with strength and resistance to the influence of loads, and the hidden crystal graphite provides a "self-lubricating" effect. The confirmation of the latter is the formation of a transfer layer on the friction surface of the steel counterbody. Based on the obtained results, polyreinforced PCM sample № 4 is recommended for use as an AFF of rolling bearings of tribological units of equipment of modern technology which work in conditions of friction without lubrication and under the influence of high temperatures (473–523 K) and dust.

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# Development of Electronic Waste Management Framework at College of Engineering, Design, Art, and Technology

By Nakeya Zahara, Olupot Peter, Wafula Simon Peter, Obed Kamulegeya  
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**Abstract-** The worldwide use of information and communications technology (ICT) equipment and other electronic equipment is growing. There is growing amount of equipment that becomes waste after its time in use. This growth is expected to accelerate since equipment lifetime decreases with time and growing consumption. As a result, e-waste is one of the fastest-growing waste streams globally. The United Nations University (UNU) calculates in its second Global E-waste Monitor 44.7 million metric tonnes (Mt) of e-waste were generated globally in 2016. The objective of the study was to develop a framework for improving e-waste management at the College of Engineering, Design, Art, and Technology (CEDAT). This was achieved by breaking it down into specific objectives, and these included the establishment of the policy and procedures being used in e-waste management at CEDAT, the determination of the effectiveness of the e-waste management practices at CEDAT, the establishment of the critical challenges constraining e-waste management at the College, development of a framework for e-waste management.

**Keywords:** e-waste, treatment, disposal, computers, model, management policy and guidelines.

**GJRE-A Classification:** LCC: TK1055



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# Development of Electronic Waste Management Framework at College of Engineering, Design, Art, and Technology

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**Abstract-** The worldwide use of information and communications technology (ICT) equipment and other electronic equipment is growing. There is growing amount of equipment that becomes waste after its time in use. This growth is expected to accelerate since equipment lifetime decreases with time and growing consumption. As a result, e-waste is one of the fastest-growing waste streams globally. The United Nations University (UNU) calculates in its second Global E-waste Monitor 44.7 million metric tonnes (Mt) of e-waste were generated globally in 2016. The objective of the study was to develop a framework for improving e-waste management at the College of Engineering, Design, Art, and Technology (CEDAT). This was achieved by breaking it down into specific objectives, and these included the establishment of the policy and procedures being used in e-waste management at CEDAT, the determination of the effectiveness of the e-waste management practices at CEDAT, the establishment of the critical challenges constraining e-waste management at the College, development of a framework for e-waste management.

The study population was 80 respondents, from which a sample of 69 respondents was selected using simple and purposive sampling techniques. This research was carried out to investigate the problem of e-waste and come up with a framework to improve e-waste management. The study reviewed the e-waste regulatory framework used at the college and then collected data, which was used to come up with a framework. The study also established that weak policy and regulatory framework, lack of proper infrastructure, improper disposal of e-waste and a general lack of awareness of the e-waste and the magnitude of the problem are the critical challenges of e-waste management. In order to appropriately address the issue, the policy and regulatory framework should be updated, localized, and strengthened. It will be helpful to launch awareness campaigns, create the necessary infrastructure, and conduct significant research to determine the scope and severity of the issues. The study suggests a framework for e-waste improvement.

**Keywords:** e-waste, treatment, disposal, computers, model, management policy and guidelines.

## I. INTRODUCTION

The worldwide use of information and communications technology (ICT) equipment and other electronic equipment is growing and consequently, there is a growing amount of equipment that becomes waste after its time in use [1]; [2]. This growth is expected to accelerate, since equipment lifetime decreases with time and growing consumption [3]. As a result, e-waste is one of the fastest-growing waste streams globally [4]. The United Nations University (UNU) calculates in their second Global E-waste Monitor, 44.7 million metric tonnes (Mt) of e-waste were generated globally in 2016 [5]. The annual global consumption of new electrical and electronic equipment (EEE) was around 60 Mt in 2016 [6]. Globally, approximately 53.6 million tonnes of e-waste were generated in 2019 [7], of this amount generated, less than 13% was recycled and the rest ended up in landfills or incinerators creating enormous environmental and health concerns due to the presence of hazardous materials [8]. The consumption and use of EEE is probably most prevalent in the developed world, but developing countries show a rapid growth of consumption and use of EEE. Typically, developed countries have growth rates of 1% to 5% annually on weight basis, developing countries typically range from 10% to 25% [5]. Some less-developed countries lack waste treatment infrastructure, waste management laws and enforcement [9]. As a result, the e-waste in those countries will often be treated in sub-optimal ways by the informal sector [10]. This leads to severe consequences for the environment and human health [11]. To treat e-waste in an environmentally sound manner, it needs to be regulated [12]. This means that an appropriate system needs to be created and financed, a recycling infrastructure needs to be developed or improved, and workers' health and safety standards need to be implemented, to name a few prerequisites [2].

A quantitative and qualitative assessment of e-waste was carried out by United Nations Industrial Development Organization (UNIDO) in Uganda in 2008

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[13]. Analysis of the data indicated that about 2,000 tons of e-waste is generated each year and not disposed in a well-planned and managed manner [9]. Equipment is dumped on outdoor garbage heaps and landfills, thus becoming a danger to human beings and the environment [14]. For developing countries such as Uganda, effective electronic waste management is a topical issue, particularly because a large percentage of e-waste is generated through imports and there is careless and uncontrollable dumping in landfills [15]. Most of the consumers, sellers, producers, importers, and other stakeholders are oblivious of the specific and key roles to play for effective and efficient management of e-waste to make the environment safe and healthy [16]. An effective strategy should focus on e-waste diversion and minimization [17]; [18]. The key challenges to electronic waste management include,

absence of proper processing facilities, lack of recycling guidelines for electronic waste management, limited capacity building and knowledge sharing on e-waste, non-implementation of the e-waste policy framework [19]. This study established the current e-waste management status at the College of Engineering, Design, Art and Technology (CEDAT) Makerere University, identified strengths, weaknesses and proposed solutions to the issues identified.

## II. METHODOLOGY

The study was carried out at Makerere University (CEDAT), which is the center of Technology and innovation. Therefore, the study population constituted of CEDAT staff.

*Table 1:* Total population, sample size and sampling techniques

| Category                     | Population(N) | Sample size(S) | Sampling Techniques    |
|------------------------------|---------------|----------------|------------------------|
| <b>Officers</b>              | 4             | 4              | Purposive sampling     |
| <b>System Administrators</b> | 1             | 1              | Purposive sampling     |
| <b>Lab Technicians</b>       | 5             | 5              | Purposive sampling     |
| <b>Institutional users</b>   | 70            | 59             | Simple random sampling |
| <b>Total Population</b>      | <b>80</b>     | <b>69</b>      |                        |

### a) Nature and Sources of Data

The study used both secondary and primary data sources. Secondary data was collected to generate study population and literature review while primary data was collected directly from respondents on the issues regarding E-waste.

Data collected was aimed at addressing the study objectives. Regarding the first objective both primary and secondary data were collected with the aim of determining the strength and weaknesses, gaps and contextual applicability of the policy and other regulatory framework governing e-waste at CEDAT. Data was mainly qualitative.

In relation to objective two and three on determining the effectiveness of the e-waste management practices at CEDAT and establishing the critical challenges primary and secondary data was collected from respondents through interviews and questionnaire and data was both qualitative and quantitative.

In relation to the last objective, both primary and secondary data collected was used to develop the e-waste framework management.

### b) Data Collection Methods

#### i. Interviews

Semi-structured interviews were selected to carry out this research study. Interviews were conducted with either sections leaders or managers to gather their views on e-waste management practices. This allowed the participants to elaborate and provided more flexibility, range and therefore the capacity to elicit more information from them. Semi-structured interviews permit scope for individuals to answer questions more on their own terms than the standardized interview permits, yet still provides a good structure for comparability over that of the focused interview [20].

#### ii. Questionnaire Administration

Questionnaire administration is the act of using a questionnaire to elicit information in a face-to-face setting, where the researcher administers the questionnaire directly, in a tele-interview by phone or some other digital means. Questionnaire administration was selected as a method because it allows for the collection of considerable amounts of data in a relatively short time and at relatively little expense while at the same time enhancing respondent anonymity [21]. A set of questions was prepared, printed, and distributed to

the respondents who answered the questions before the researcher collected the filled questionnaires.

### iii. Document Review Analysis

Document's review was used to collect secondary data during the study to support and validate facts. Documents such as the e-waste management policy, strategy and guidelines for e-waste, articles, journals, and reports on e-waste management were reviewed. These helped the researcher get an internal view of the e-waste management.

### iv. Data Collection Instruments

Data collection was carried out using the following tools;

#### v. Interview Guide

In-depth interviews were conducted using the interview guide. The interview guide was semi-structured. The method enabled the researcher to collect accurate information from the officials who were selected to participate as key informants; because, they had a wealth of experience and knowledge on e-waste management. The instrument well ensured that reliable information is gathered, because it facilitates a deeper investigation into the topic under study. It helped the researcher to explain or clarify questions thereby increasing likelihood of useful responses.

### vi. Documentary Analysis Checklist

The researcher developed a checklist to guide the reading and contained possible reading and sources of information. This included documents pertaining to the policy frameworks, strategies, guidelines, and e-waste management practices.

### vii. Questionnaires

Self-administered, structured questionnaires were used to collect quantitative data. The questionnaire was close-ended and based on the five-point Likert scale. Although a structured questionnaire has the intrinsic disadvantage of preventing respondents from expressing themselves more authentically in their own words, this type of questionnaire was preferred because it can limit inconsistency and it saves time. The researcher distributed the questionnaires to the respondents for completion, after which they were collected at a later time on the same day. The use of the questionnaire was motivated by the fact that the targeted respondents were literate and, therefore, capable of completing the questionnaires on their own, thereby saving the researcher time and money. Moreover, self-administered questionnaires were known to have the potential to generate reliable and unbiased information on account of the fact that the respondent completes the questionnaire in the absence of the researcher [21].

## III. RESULTS

### a) Response Rate

The study applied questionnaires and interview guide to collect data from the respondents. The instrument yielded and overall response rate as presented in Table 2.

Table 2: Response rate of the various respondents

| Respondents/<br>categories            | Method            | Target | Actual | Response<br>rate |
|---------------------------------------|-------------------|--------|--------|------------------|
| <b>Officers</b>                       | Interview         | 4      | 4      | 100%             |
| <b>System<br/>administ<br/>rators</b> | Interview         | 1      | 1      | 100              |
| <b>Lab<br/>technicians</b>            | Interview         | 5      | 3      | 60%              |
| <b>Institutional<br/>Users</b>        | Questi<br>onnaire | 59     | 60     | 88%              |
|                                       | Total             | 69     | 60     | 87%              |

It was of paramount importance to compute the response rate to establish whether it was adequate for the generation of the required data. Out of a sample of 69, 60 (87%) responded while 13% were not in position. The response rate of 87% was adequate to facilitate this study which implies that the data can be relied on and that the study findings were representative of the population.

Table 3: Thematic framework

| Interview Themes  | Coding framework/                  | Comments on main themes   |
|---|------------------------------------|---|
| Policy and Regulatory framework                                 | Policy                             | Policy and regulatory framework too weak to handle the e waste problem.         |
|   | Regulatory framework.              |   |
|   | National E-waste management policy |   |
|   | Institutional policy               |   |
|   | Contextual Applicability           |   |
|   | Implementation                     |   |
| Practices and effectiveness of the E waste management practices | Enforcement                        | Only a single practice is employed at the disposal stage and not effective      |
|   | Awareness                          |   |
|   | Practices                          |   |
|   | Effectiveness of practices         |   |
|   | Sustainability                     |   |
| Critical challenges   | Goal oriented                      | Properly addressing the mentioned Challenges is critical to e waste management. |
|   | Critical challenges                |   |
|   | Generation challenges              |   |
|   | Treatment challenges               |   |
|   | Disposal challenges                |   |

## b) Length of Service

The responses were sought from the respondents on the length of service in the organisations and the findings are provided in Figure 1.

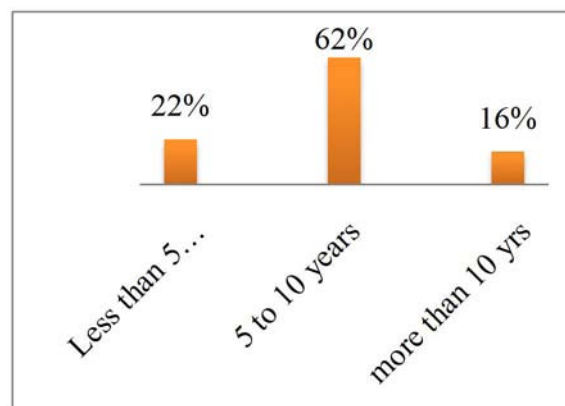


Figure 1: Length of service of the respondents

62% had worked for 5-10 years, 22% for less than 5 years and 16% for more than 10 years. Since most of the respondents had worked for more than 5 years they have gained relevant experience and knowledge on issues of e-waste. It also depicts work experience representativeness of the respondents.

#### c) Qualitative Findings

A thematic framework as shown in Table 3 was developed to analyze the data qualitatively and identify the common theme.

#### d) Findings on Policy and Regulatory Framework

Qualitatively, the interviews revealed that the college has no policy that comprehensively covers e-waste problem as a whole that is to say from generation to disposal but they rather follow the University disposal policy for ICT equipment.

They are required by law to implement a sustainable environmentally friendly electronic waste disposal which they have designed. However, findings from the research shows that little have been done to implement this policy and one can comfortably state that there has been no implementation.

Interviews revealed that the disposal policy advocates for salvaging and reassembling of e-waste, donations or sale of obsolete hardware through auction. This however is not followed; the institute e-waste hardly ever disposes of e-waste in the above ways but rather as revealed by one of the interviewees as highlighted below.

*"We keep the e-waste in the stores and the university estate department picks it up for auctioning however this takes long due to limited funding"*

Another one revealed that.

*"Currently all government bodies keep the e-waste in their offices and await the review of the PPDA act to include e-waste as a category".*

Responses are shown in the figure 2.

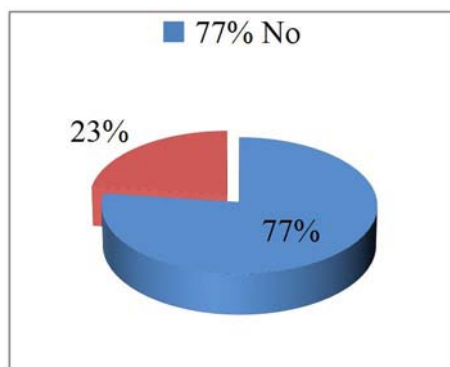


Figure 2: Efficiency of National Policies in Addressing E-waste Management in Uganda

From Figure 2, 77% of the respondent thought that the national policies do not efficiently address the

problem of e-waste, while 23% thought the policies fully address the problem of e-waste. Many of the 77% level claimed that the national policies do not directly address the problem of e-waste but address waste a whole, they also claimed that enforcement of the regulation has proved to be a problem by NEMA and there is no control in the sector. They also thought that the government does not provide enough financial support to bodies that are involved in environmental management such as NEMA hence such bodies cannot efficiently carry out their mandate. Yet actually the government offers support through the guidelines for e-waste management in Uganda.

#### e) Quantitative Findings on Policy and Regulatory Framework

Quantitative findings are as per Table 3. Details of questions asked on policy and regulatory framework (frequencies and percentages) for interpretation purposes both agree and strongly agree show agreed scores; not sure are not combined while strongly disagreed and disagreed represent disagreed scores. Key quantified findings reveal that 50% (n=49) respondents are not aware of the e-waste management policy while 46.6% of the respondents were aware of the policy, 3.3% were undecided. Similarly, 45% of the respondents were aware of the existing legal and regulatory framework on e-waste management while 50% were not aware and 5% were not sure. On whether the existing e-waste management policy is sufficient to manage e-waste, 78.3% of the respondents disagreed while 16.7% agreed and 5% were not sure. 80% of the respondents don't believe the available laws for e-waste management are enforced while 16.7% agreed that they are enforced and 3.3% are not sure. 13.3% of the respondents agreed that CEDAT follows the e-waste management regulatory framework while majority of the respondents (83.6%) disagreed and 3.3% were not sure.

Regarding the framework's applicability 21.7% agreed that it was easy to apply while 75% disagreed. On whether it is appropriate 73.4% don't think it is while 23.4% think it is appropriate and 3.3% were undecided. Regarding the effectiveness of the framework, 20% of the respondents believe it is while 76.7% do not believe the framework is effective.

These results suggest that there is limited awareness of the policy and regulatory framework at CEDAT and even amongst the respondents who may be aware of the policy and regulatory framework, many don't believe it is applicable, appropriate, and effective. The findings can be supported by a key respondent who said that.

*"The management of e-waste at CEDAT is mainly impacted by limited awareness of policies and regulatory framework on e-waste and there is need for sensitization, even with the presence of the institutional*



policy, the institute is limited by the PPDA act which is mostly silent on major issues of e-waste”.

f) *Findings on Practices and Effectiveness of E-waste Management*

With the objective of determining the effectiveness of existing e-waste practices in Uganda, the researcher looked at the current practices used in the management of e-waste that is looking at how it is created, how it can be reduced to methods of disposal. The study examined the effectiveness of these practices in terms of their ability to achieve the ultimate objectives of reducing e-waste, proper disposal, safeguarding both human life and the environment from the harmful effects of improper e-waste management. Below is a presentation of study findings:

E-waste is mainly generated through purchase and use of ICT equipment since the university is one of highest consumer organizations of ICT equipment.

Regarding disposal, CEDAT policy advocates for salvaging and reassembling, sale of hardware, hardware donations and hardware destruction, however there are not clearly defined, or proper hardware destruction procedures followed, and the most common way is storing it in a designated store as they await the opening of the e-waste disposal center. The college does not keep track of these e-waste.

The PPDA act is silent on e-waste disposal in government institutions therefore e-waste cannot be disposed of until changes are enacted. Findings reveal that the practices employed by the institute are not effective as stated by one the interviewees. The probable solution to diminish e-waste is through recycling and reusing.

“There is need for better guidelines and practices to address e-waste as the ones we are presently following are not helping”. On whether the practices reduced the impact on the environment and human life. Most of the interview respondents did not believe so; one opined that.

“By keeping away the waste in a store may not directly bring harm to the environment and humans now but we know that we can't have waste lying in a store somewhere, that doesn't really solve the problem but just delays solution, so I don't think we are reducing the impact of e-waste on the environment or human life, we are simply not doing anything about it”.

While another said that.

“As long as we are still purchasing EEE and not properly disposing it off well, we are not managing it effectively. What we are doing is not sustainable”.

The findings suggest that the practices employed at CEDAT to manage e-waste are not effective since they are not sustainable solutions to the problem as per the respondents and the figure 3 is a representation of their overall responses.

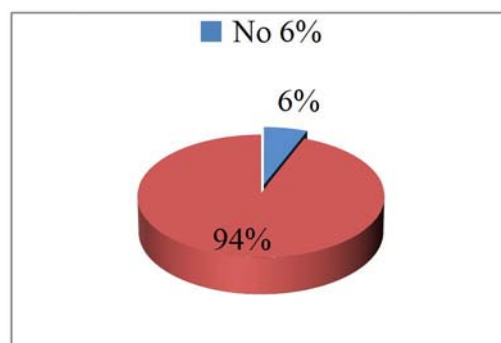


Figure 3: Effectiveness of Practices in Addressing e-waste

6% of the respondents accredited especially the practice of putting away the e-waste in a designated store until an e-waste collection center is allocated as one of the ways the institute has contributed to the overall management of e-waste as unplanned dumping would cause more harm than good to the population. 94% of the respondents thought this practice does not fully address the issue of e-waste. They also attributed ineffectiveness of the practices to poor enforcement and thought that the institute should introduce of practices that effectively manage e-waste that is right from generation to disposal. The ineffectiveness of the practices employed to address key issues regarding e-waste has raised many challenges regarding e-waste handling which has escalated the problem.

The results reveal that though some respondents agreed that there are e-waste management practices at CEDAT many of the respondents did not think that the practices are effectiveness to manage the problem. These results suggest that there is little adherence to e-waste management practices at CEDAT and that the practices may not be effective in combating the ultimate impact of e-waste on the environment and human life. The findings can be supported by a key respondent who said that the only practice we employ to manage e-waste is storing the waste which ideally is just putting off the problem but not solving it”. Key quantified findings reveal that 41.7%% (n=25) respondents believe that the institute has practices used to manage e-waste while 51.7% don't believe there are practices and 6.7 are not sure.

On whether the practices are adhered to only 10% agreed while 86.6% don't believe the practices are adhered to. Regarding the effectiveness of the applied practices in e-waste management 71.6% of the respondents do not believe they are effective while 21.6% believe that the practices are effective in managing e-waste at CEDAT. 80% of the respondents believe that the practices used to manage e-waste do not reduce the impact of e-waste on the environment while 16.7% agreed that they reduce the impact of e-waste on the environment. 3.3% were not sure, similarly

78.4% of the respondents disagreed to the statement that the practices used help reduce the impact of e-waste on human life while 18.4% agreed to the statement and 3.3% were not sure. This indicates that the applied practices in e-waste management are not effective.

#### g) Findings on Critical Challenges of E-waste

The interviews demonstrated that there exist challenges in management of e-waste at CEDAT. Among the many challenges put forward by the interviews were lack of awareness of e-waste and magnitude of the e-waste problem, lack of sensitization, limited funding, lack of stakeholder/employee engagement, Political interference, weak policies and regulatory framework, informal disposal methods, lack of disposal facilities no enforcement among others. The major challenges put forward were mainly lack of awareness of e-waste and poor disposal of the waste.

The study established that e-waste is never completely disposed but put away in a store. This means that the waste stays at the premises for an unprecedented amount of time as one of the interviewees revealed that.

"The waste stays here for a very long time and most times ends up in wrong hands or stolen".

"Waste is relative, the obligation of disposal is not put in consideration since it is not sensitive and due to cost."

On the issue of awareness, it was established that most of the respondents had limited knowledge

about e-waste and the e-waste problem. Though they admitted having heard about e-waste through media, they did not view it as a major issue. Equipment is used past obsolesce and not properly disposed due to lack of awareness. The impact of e-waste on human life and the environment is not thought about due to the limited knowledge of what e-waste is and potential impact.

The general knowledge on e-waste is very important as it is the very first critical stage in fighting e-waste at any level therefore training and capacity building should be undertaken to enlighten people on the matter.

One of the interviewees stated that.

"Many people here don't know so much about e-waste all they know is whether the machines they use is working or not and if it is functional then all is well, but if it is not then all they care for is how to get a new one, proper disposal of the old one is the least of their concerns".

On whether there any measures put in place to minimize the challenges interviews revealed that there is none as the PPDA act limits what they can and can't do about e-waste. One of the interviewees opined that.

"We are guided by the government under the PPDA Act and that limits us as the Act is silent on important issues like disposal of e-waste".

Figure 4 is a graphical representation of the respondents' views on the critical challenges of e-waste management.

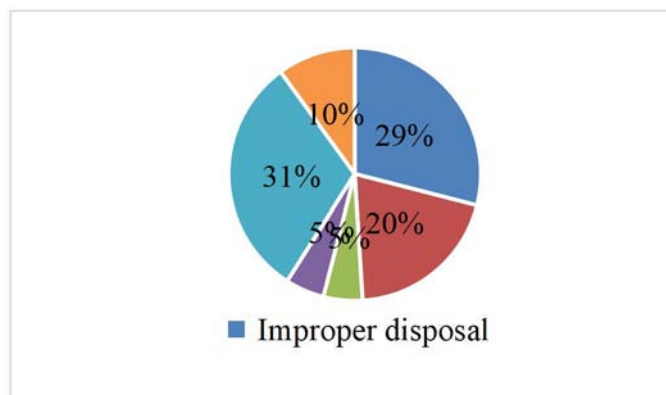


Figure 4: Findings on Critical Challenges of E-waste

Overall, the respondents revealed that weak policies and regulatory framework is the biggest challenge to e-waste management followed by improper disposal, lack of awareness about e-waste and its implications as well as poor infrastructure, stakeholder/employee engagement and lack of enforcement. Failure to address these challenges will only worsen the problem.

The results reveal e-waste was not prioritized at CEDAT, and even with the presence of ICT policies, enforcement is lacking. These results suggest that e-

waste is not properly managed at the institute and the e-waste problem has not been given the necessary attention it deserves; the findings can be supported by a key respondent who said that.

"It's not something people pay attention to here. The policies are not enforced due to constraints in funding".

Key quantified findings reveal that 81.6% (n=49) respondents don't believe the institute has guidelines for e-waste treatment, however 15% (n=9)

agreed that there are guidelines on e-waste treatment and 3.3% n=2 were undecided.

On whether e-waste management is prioritized at the institution 88.4% of the respondents disagreed while 10% think it is prioritized and 1.7% are not sure.

Regarding policies on waste disposal 76.6% agreed that the institution has e-waste disposal policy however 18.3% disagreed and 5% were not sure. This suggests that regarding e-waste disposal, the institute has a policy in place however one of the key informants stated that.

"The ICT disposal policy that we have doesn't effectively manage the problem, we put e-waste in stores which doesn't solve the problem. We need a better disposal policy".

On whether the policies are followed and enforced 80% of the respondents disagreed while 16.7% believe they are followed and 3.3% were not sure.

#### IV. DISCUSSION AND FINDING

##### a) Discussion of the Findings

##### b) Existing E-waste Management Policy and its Implementation

The study findings revealed a gap in the policy and regulatory framework at CEDAT. e-waste management requires that it is managed from generation (ecofriendly devices) till it is disposed of and this should be in a way that does not harm human life and the environment. The institute has a disposal policy but lacks a comprehensive e-waste management policy. Even within the disposal policy the study revealed a number of gaps. The absence of a comprehensive e-waste management framework coupled with ineffective/lax implementation of the existing disposal policy is one of the major reasons of the low-end management of e-waste.

The study also revealed limited awareness and knowledge about the e-waste policy and regulatory framework of the country which one would expect most of them to be aware of since this is a government institution, for those that were aware about it, they did not think it is applicable, appropriate, and effective and the same goes for the university ICT disposal policy that is followed by the institute. This finding is in concurrence with [22] who in their study revealed that all the five East African countries lack concrete regulations for e-waste, yet the number of ICT users is continuously growing and that in all these countries governments are well aware of the seriousness of this problem. Also, in agreement was a study carried out by [5], who found that e-waste legislation is absent in large parts of Africa.

The laxity in implementation and enforcement is partially attributed to lack of a specific department to address e-waste at the institute, therefore there is need to formulate an independent department to ensure wholesome accountability in matters of e-waste.

The importance of a strong policy and regulatory framework is key in e-waste management. The legislation should be enforceable and implementable. This is line with the study findings by [23] who stated that legal regulation is very essential in designing WEEE management system.

##### c) Practices and Effectiveness of the Existing E-waste Management Practices

Study findings revealed that the practices employed to manage e-waste at CEDAT were ineffective, inefficient, and not sustainable. The college has ignored practices that can help combat the problem regarding generation and treatment. It has concentrated on disposal which basically looks at salvaging, reassembling, sale and donations of hardware. EEE was found to be used past obsolescence and if functional, it is still useful.

Study findings by [24] suggested that prevention of creating waste material is an important method of waste reduction and though this can be cheaper in the long run however, this has not been considered by the institute. Practices such as adapting a circular economy and purchase of durable, original, and quality EEE products will also reduce on the degree and rate of e-waste generation while other practices recommended in the next chapter are sought to help effectively manage the problem.

Further findings of this study reveal that CEDAT has very weak measures for addressing the problem of e-waste and general environmental health and safety guidelines; this includes policies on e-waste, e-waste handling procedures and environmental health and safety measures. Therefore, e-waste is characterized by ineffective generation, treatment, and disposal methods.

E-waste is thus proving to be a serious emerging environmental challenge, which requires urgent attention at all levels. According to [25], there is a need for more developing countries to enact policies that guide the management of e-waste in order to prevent environmental degradation and adverse effects on human health. There is no quantifiable data to determine the exact amount of e-waste there is at CEDAT, therefore estimation of future trends of e-waste is hard. The study further revealed that a lot of e-waste has been stored in the offices awaiting legislation on disposal, this is in line with [26] findings that assert that in Africa e-waste is disposed of inappropriately; the majority of obsolete EEE being stored in offices awaiting future solutions. According to [27], most outdated electronic equipment is typically stored for some time due to a perceived worth (physical or emotional) before being disposed of. The author went on to say that these artifacts are typically kept in storage in both public and private facilities until orders are given for their disposal. In terms of e-waste disposal techniques, CEDAT stores e-waste as opposed to using other techniques. This

implies that other e-waste disposal strategies, like reuse, renovation, and recycling initiatives, were weak. The above findings suggest that practices employed at the institute are not good practices and are ineffective in managing the problem. This means that the problem is not sufficiently managed and better and demonstrates an urgent need to put in place good practices to ensure smarter and more sustainable e-waste management.

#### d) *Findings on Critical Challenges of E-waste*

The study revealed that weak policies and regulatory framework is the biggest challenge to e-waste management at CEDAT, this coupled with near absence or ineffective implementation of the existing regulations worsens the problem. As a government agency, CEDAT is constrained by the government in what it can do to address the issue and is negatively impacted by the national e-waste management policy's uneven implementation and enforcement. In agreement is a study by [28] who found that the absence of e-waste specific policies presents a challenge in coordinating e-waste management roles and responsibilities. [29] found that the absence of e-waste legislations or absence of frameworks, in Ethiopia limited the actions and reactions of the stakeholders towards e-waste management in the country.

This reveals the importance of a contextually applicable policy and regulatory framework both at national and institutional level in addressing the e-waste problem. This however should not come short of all the resources that facilitate its implementation and enforcement to achieve results. [30] asserts that development of firm policies and the use of efficient technologies have been described as critical in e-waste management.

Another challenge established by the study was improper disposal of the e-waste at the institute which is sought to be one of the main reasons why the e-waste levels are going up. This is coupled with the absence of infrastructure for the recycling, and appropriate management/disposal of e-waste following the principles of sustainable consumption/development. There are no proper disposal facilities, and the operating disposal policy has numerous limitations. This reveals inefficiency, and ineffectiveness of the disposal practices as applied by the institute, a study by [31] reveals that one of the key factors to consider in successful management of e-waste is disposal of e-waste by suitable techniques. It is therefore wise to consider options like recycling and other good practices of e-waste management to combat the problem.

Findings revealed limited awareness of e-waste and magnitude of the e-waste problem. There is limited awareness of the potential hazards of e-waste to human health and the environment and the problem is thereby not given the urgent attention it deserves. This finding concurs with [32] that one of the major challenges of e-

waste management in developing countries is ignorance of the toxicity or hazardous nature of e-waste in government and public circles. Also, in agreement is [33], who found that most e-waste consumers had poor knowledge on its management specifically on handling and disposal which they attributed to lack of sensitization and system to manage e-waste. This suggests that awareness is a very crucial factor in dealing with e-waste and therefore awareness campaigns should be intensified by the relevant stakeholders to address the current gap.

Other challenges established by the study were lack of sensitization, lack of proper infrastructure, lack of stakeholder/employee engagement, political interference. All these need to be addressed for proper management of the problem, in agreement with [23]. [23] revealed that some of the reasons behind the present low-end management of WEEE in the developing countries is the absence of infrastructure and lack of awareness among consumers, collectors and recyclers of the potential hazards of WEEE.

## V. FRAMEWORK DEVELOPMENT

### a) *Proposed Framework for Improved E-waste Management*

Regarding the study findings and lessons learnt from countries that have managed to effectively deal with the e-waste problem, the researcher believes that the proposed framework presents a unique and ideal solution to the e-waste problem at CEDAT and can also be adopted by the country at large. The framework looks at the material flow of e-waste from generation to collection, illustrates a clearly defined e-waste collection system and key inputs. For effective management of e-waste, the framework proposes mandatory implementation of EPR spear headed by government, the establishment of product reuse through remanufacturing and the introduction of efficient recycling facilities. It should offer financial incentives based on weight to individuals that collect e-waste from the community and bring it to the collection centers for recycling to motivate people to use the facilities.



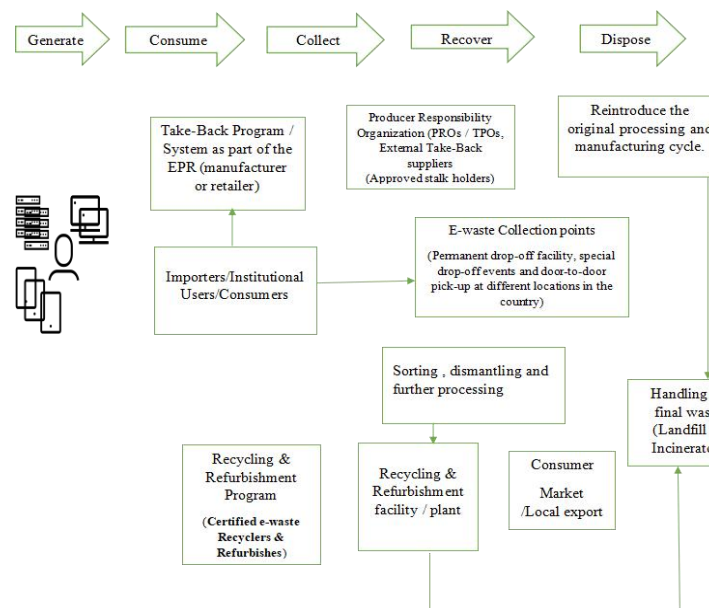


Figure 5: Proposed Framework for Improved E-waste Management

The proposed framework for improved e-waste management implores the various e-waste management approaches like; Takeback system & Collection plant which were studied by [27]; [34]; [35]; [36], as well as a study on Refurbishment & Recycling and-Repurpose by [37]; [38].

## VI. DISCUSSION OF RESULTS

### a) Existing E-waste Management Policy and its Implementation

The study findings revealed a gap in the policy and regulatory framework at CEDAT. e-waste management requires that it is managed from generation (eco-friendly devices) till it is disposed of and this should be in a way that does not harm human life and the environment. The institute has a disposal policy but lacks a comprehensive e-waste management policy. The absence of a comprehensive e-waste management framework coupled with ineffective/lax implementation of the existing disposal policy is one of the major reasons of the low-end management of e-waste.

The study also revealed limited awareness and knowledge about the e-waste policy and regulatory framework of the country which one would expect most of them to be aware of since this is a government institution, for those that were aware about it, they did not think it is applicable, appropriate, and effective and the same goes for the university ICT disposal policy that is followed by the institute. This finding is in concurrence with [39] who in their study revealed that all the five East African countries lack concrete regulations for e-waste, yet the number of ICT users is continuously growing and that in all these countries governments are well aware of the seriousness of this problem. Also, in agreement was a study carried out by [5] who found that e-waste legislation is absent in large parts of Africa.

The laxity in implementation and enforcement is partially attributed to lack of a specific department to address e-waste at the institute, therefore there is need to formulate an independent department to ensure wholesome accountability in matters of e-waste.

The importance of a strong policy and regulatory framework is key in e-waste management. The legislation should be enforceable and implementable. This is line with the study findings by Nnorom & Osibanjo, (2008) who stated that legal regulation is very essential in designing WEEE management system.

## VII. CONCLUSION

*The study draws the following conclusions;*

The policy and procedures being used in e-waste management at CEDAT suffer limited awareness and appreciation from the policy implementers. This makes e-waste management ineffective and slows the process of enforcement and implementation of the policy. Policy sensitization and amendments are required, and various stakeholders should be trained on its purpose and the importance of constantly reviewing it for guidance on e-waste management.

The study also realized a limited awareness among the policy implementers and other stakeholders, which also weakens the implementation of the policy. The practices employed at the college were inefficient and unsustainable to solve the e-waste problems at the college.

The policy employed at the college ignores key practices of e-waste management that could help combat the problems of e-waste. The weak policy and its poor procedures worsen the problem.

According to the framework, transportation of e-waste is a priority issue in e-waste management. It is

important that this waste is safely handled, and this can only be achieved through provision of necessary infrastructure to help in management of e-waste. As per the framework, collection centers play a great role in enabling proper handling of e-waste therefore setting them up at points that are easily accessible to the communities. The framework advocates for partnerships between the government and private firms through Public-Private-Partnerships (PPP) to build robust and sustainable infrastructure to facilitate an environmentally friendly e-waste management system and provide incentives for consumers to dispose their e-waste. However, the framework identifies a sound policy and a regulatory framework that tackles all components of e-waste management. Which should be implemented to reduce on the e-waste dumped and also push part of the responsibility to the producer organizations. The regulations should be applicable to all processes that involves e-waste.

#### a) Recommendations

Based on the conclusions, the following recommendations are proposed:

- The Government should bring to public awareness the existing policy and legislations in place, implement e-waste policy, formulate and enforce legislation that is specific to e-waste management.
- The college should adopt practices that comprehensively manage e-waste from generation to disposal. Designing modified EPR strategies based on the local economy and capacity to implement such schemes could come in handy. In addition, adopt modified EPR schemes that include regulatory approaches on electronic equipment to procure green products using less hazardous materials (i.e., implement DfE criterion or eco-design/cleaner production) and then, subsequent e-waste management processes will be cheap and easy.
- Consider adopting recycling as a strategy for managing e-waste, this can be through engagement in Private Public Partnerships, together they can create a solution for developing recycling infrastructure in e-waste, however they need to be designed carefully regarding Legislations and Regulations, Financial and Organizational Risks, Local Community Involvement and Financial Incentives.
- Invest in awareness and education campaigns, capacity building, training and knowledge sharing on e-waste management and carry out extensive research to establish the volumes, nature and potential environmental and human impact to bridge the knowledge gap about e-waste.

The adoption of a model where consumers in this case institutional users take e-waste to certified e-

waste collectors who pay them (incentives). Then the collectors could sell to recyclers or refurbishers. This could drive e-waste collection, transportation, and its treatment, as is the case in Sweden.

#### b) Limitations of the Study

The rampart lockdowns due to Covid-19 in the country greatly affected the institute and hence the data collection process.

Another limitation to this research was inadequate time and money available to the researcher to conduct the study. Secondly, the tendency of many employees to paint a rosy picture of their organization, especially when they are communicating to strangers, and the resultant reluctance to disclose unfavorable information, lest they be construed as inefficient, must also have limited the scope of the data collected.

#### c) Future Perspectives

Researchers in e-waste should consider areas related to.

- i. Reduction of e-waste generation
- ii. Recycling of e-waste: cost vs benefit
- iii. Applicability of EPR schemes in the least developed countries
- iv. Understanding e-waste disposal techniques: Determinants, policy implications, challenges, and prospects.
- v. The impact of policy and Regulatory framework on e-waste management.

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I am grateful to God for the good health and well-being that allowed me to finish this study.

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## A Rubric Report 2023 R “The Profile of a Post Doctoral Research”

By V. Githaguru

*Introduction-* Pioneering experiments with promising results and ironically lay unpublished is paradoxical. But that is what had happened to him as the another, years ago, in 2013. Yet, the continuing relevance of the ideas and similar pursuit by others, prompted him now in 2023, to publish his “post doctoral” works; as it knowledge matters and its chronology too!

His doctoral thesis, Anna University (2008) was on “Trifemur” a wear tester for hip joint prostheses, his patented invention. Subsequently, he augmented it as a versatile tribometer for the orthopaedic implants. Dimpled femur ball, spinal discs, special coating and lubricants could get unacceleratedly test-measured for their natural wear-life span. Pilot test runs on shells and discs proved successful, it was ready to test dimpled femur ball as well.

Parallely, he was pursuing his other idea of tilt-rotor for wind-turbine, through the guided projects for students at the Crescent Engineering College, during the years 2009, 10, 11 and 2013. Results encouraged to go for prototype of the new design.

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## I. INTRODUCTION

Pioneering experiments with promising results and ironically lay unpublished is paradoxical. But that is what had happened to him as the another, years ago, in 2013. Yet, the continuing relevance of the ideas and similar pursuit by others, prompted him now in 2023, to publish his “post doctoral” works; as it knowledge matters and its chronology too!

His doctoral thesis, Anna University (2008) was on “Trifemur” a wear tester for hip joint prostheses, his patented invention. Subsequently, he augmented it as a versatile tribometer for the orthopaedic implants. Dimpled femur ball, spinal discs, special coating and lubricants could get unacceleratedly test-measured for their natural wear-life span. Pilot test runs on shells and discs proved successful, it was ready to test dimpled femur ball as well.

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In the midst of it all, came the retirement in 2013 at his age 65 and the abrupt freeze of the these projects due to self-imposed oblivion. Then personally, he kept himself play-fit all along by musing nonlinear dynamics, spacetime curvature, stability of the wind turbine blades and all that. Meanwhile, the efficacy of the dimpled ball in the hip joint vouched by the Arkansas University U.S., the potential of tilt-rotor wind turbine published by Korean- Japanese team in another journal, came to his notice and triggered a positive change in the beginning of 2022.

Both of his ideas gaining momentum enthused him as a pioneer! the who initiated the dimpling of femur ball, at the Indo-Japan conference I.I.T (Madras) as early as 2004 even before his Ph.D, got invigorated to salvage his “post doctoral” works freezing since 2013 and put them public for what so ever its worth.

From Jan. 2022, he resumed working on those frozen records, alone as an emeritus professor and consolidated his research findings in Jan 2023, as rubric reports entitled:-

- Augmented “Trifemur” as versatile tribometer and the efficacy of dimpled femur ball in bettering the lubrication!

- Tilt & Swivel type wind rotor for harnessing high winds, and the pleasant spin-off, of its kinetic resemblance to that of the Kovalevskaya- Top, a legendary, mathematician's work.

Reporting of these two ideas: Trifemur and Tilt rotor as a sequel to their pioneering emergence decade ago and grooving relevance globally, delights the another and hopefully the reader too. Hence it is termed as rubric report R̃ – a distinguished one.

## II. ENGINEER/INVENTOR/AWARDS

Received his B.E. Mechanical Engineering (1970) degree from the Madras University, M.S. in Aero Dynamics (1990) from I.I.T, Madras and the Ph.D in Bio Mechanics (2008), from Anna University, Tamilnadu, India.

He is having vast industrial and research exposure in addition to his service in teaching. His research contributions are recognized with as National Research and Development Corporation Govt. of India NRDC Award for invention (1979), WIPO Gold Medal from the Intellectual Property organization, Geneva (1980) and Key Achiver Citation from the Technology Magazine U.S.A (1981) he has two patents for his inventions and his areas of interest in teaching and research include:- Bio mechanics, Tribology, Fluid Mechanics, and Finite Element Analysis.

Had been on research fellowship to the university of Florida, U.S.A in 1980 and the university of McGill Canada in 1985, in the field of renewable energy.

### *The list of Inventions*

1. Anila– Wind devices
2. Poghil – Wind devices
3. Thoyam – Solar still
4. Harmonious structure
5. Gradesic braced cone shells
6. Trifemur – Weartester
7. Tilt rotor wind Turbine.

For about fifteen years, he served as Professor Teaching and Researching in the Departments of Mechanical Engineering, at the Crescent Engineering College, Chennai, India and retired at 65 years, in 2013.

Jan, 2023, Chennai.

### *Note on Author's Name*

Githaguru and Geethaguru both refer to the same author; phonetic identity triggers the variant spelling.



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- Page size: 8.27" x 11", left margin: 0.65, right margin: 0.65, bottom margin: 0.75.
- Paper title should be in one column of font size 24.
- Author name in font size of 11 in one column.
- Abstract: font size 9 with the word "Abstract" in bold italics.
- Main text: font size 10 with two justified columns.
- Two columns with equal column width of 3.38 and spacing of 0.2.
- First character must be three lines drop-capped.
- The paragraph before spacing of 1 pt and after of 0 pt.
- Line spacing of 1 pt.
- Large images must be in one column.
- The names of first main headings (Heading 1) must be in Roman font, capital letters, and font size of 10.
- The names of second main headings (Heading 2) must not include numbers and must be in italics with a font size of 10.

### ***Structure and Format of Manuscript***

The recommended size of an original research paper is under 15,000 words and review papers under 7,000 words. Research articles should be less than 10,000 words. Research papers are usually longer than review papers. Review papers are reports of significant research (typically less than 7,000 words, including tables, figures, and references)

A research paper must include:

- a) A title which should be relevant to the theme of the paper.
- b) A summary, known as an abstract (less than 150 words), containing the major results and conclusions.
- c) Up to 10 keywords that precisely identify the paper's subject, purpose, and focus.
- d) An introduction, giving fundamental background objectives.
- e) Resources and techniques with sufficient complete experimental details (wherever possible by reference) to permit repetition, sources of information must be given, and numerical methods must be specified by reference.
- f) Results which should be presented concisely by well-designed tables and figures.
- g) Suitable statistical data should also be given.
- h) All data must have been gathered with attention to numerical detail in the planning stage.

Design has been recognized to be essential to experiments for a considerable time, and the editor has decided that any paper that appears not to have adequate numerical treatments of the data will be returned unrefereed.

- i) Discussion should cover implications and consequences and not just recapitulate the results; conclusions should also be summarized.
- j) There should be brief acknowledgments.
- k) There ought to be references in the conventional format. Global Journals recommends APA format.

Authors should carefully consider the preparation of papers to ensure that they communicate effectively. Papers are much more likely to be accepted if they are carefully designed and laid out, contain few or no errors, are summarizing, and follow instructions. They will also be published with much fewer delays than those that require much technical and editorial correction.

The Editorial Board reserves the right to make literary corrections and suggestions to improve brevity.



## FORMAT STRUCTURE

***It is necessary that authors take care in submitting a manuscript that is written in simple language and adheres to published guidelines.***

All manuscripts submitted to Global Journals should include:

### **Title**

The title page must carry an informative title that reflects the content, a running title (less than 45 characters together with spaces), names of the authors and co-authors, and the place(s) where the work was carried out.

### **Author details**

The full postal address of any related author(s) must be specified.

### **Abstract**

The abstract is the foundation of the research paper. It should be clear and concise and must contain the objective of the paper and inferences drawn. It is advised to not include big mathematical equations or complicated jargon.

Many researchers searching for information online will use search engines such as Google, Yahoo or others. By optimizing your paper for search engines, you will amplify the chance of someone finding it. In turn, this will make it more likely to be viewed and cited in further works. Global Journals has compiled these guidelines to facilitate you to maximize the web-friendliness of the most public part of your paper.

### **Keywords**

A major lynchpin of research work for the writing of research papers is the keyword search, which one will employ to find both library and internet resources. Up to eleven keywords or very brief phrases have to be given to help data retrieval, mining, and indexing.

One must be persistent and creative in using keywords. An effective keyword search requires a strategy: planning of a list of possible keywords and phrases to try.

Choice of the main keywords is the first tool of writing a research paper. Research paper writing is an art. Keyword search should be as strategic as possible.

One should start brainstorming lists of potential keywords before even beginning searching. Think about the most important concepts related to research work. Ask, "What words would a source have to include to be truly valuable in a research paper?" Then consider synonyms for the important words.

It may take the discovery of only one important paper to steer in the right keyword direction because, in most databases, the keywords under which a research paper is abstracted are listed with the paper.

### **Numerical Methods**

Numerical methods used should be transparent and, where appropriate, supported by references.

### **Abbreviations**

Authors must list all the abbreviations used in the paper at the end of the paper or in a separate table before using them.

### **Formulas and equations**

Authors are advised to submit any mathematical equation using either MathJax, KaTeX, or LaTeX, or in a very high-quality image.

### **Tables, Figures, and Figure Legends**

Tables: Tables should be cautiously designed, uncrowned, and include only essential data. Each must have an Arabic number, e.g., Table 4, a self-explanatory caption, and be on a separate sheet. Authors must submit tables in an editable format and not as images. References to these tables (if any) must be mentioned accurately.



## Figures

Figures are supposed to be submitted as separate files. Always include a citation in the text for each figure using Arabic numbers, e.g., Fig. 4. Artwork must be submitted online in vector electronic form or by emailing it.

## PREPARATION OF ELECTRONIC FIGURES FOR PUBLICATION

Although low-quality images are sufficient for review purposes, print publication requires high-quality images to prevent the final product being blurred or fuzzy. Submit (possibly by e-mail) EPS (line art) or TIFF (halftone/ photographs) files only. MS PowerPoint and Word Graphics are unsuitable for printed pictures. Avoid using pixel-oriented software. Scans (TIFF only) should have a resolution of at least 350 dpi (halftone) or 700 to 1100 dpi (line drawings). Please give the data for figures in black and white or submit a Color Work Agreement form. EPS files must be saved with fonts embedded (and with a TIFF preview, if possible).

For scanned images, the scanning resolution at final image size ought to be as follows to ensure good reproduction: line art: >650 dpi; halftones (including gel photographs): >350 dpi; figures containing both halftone and line images: >650 dpi.

Color charges: Authors are advised to pay the full cost for the reproduction of their color artwork. Hence, please note that if there is color artwork in your manuscript when it is accepted for publication, we would require you to complete and return a Color Work Agreement form before your paper can be published. Also, you can email your editor to remove the color fee after acceptance of the paper.

## TIPS FOR WRITING A GOOD QUALITY ENGINEERING RESEARCH PAPER

Techniques for writing a good quality engineering research paper:

**1. Choosing the topic:** In most cases, the topic is selected by the interests of the author, but it can also be suggested by the guides. You can have several topics, and then judge which you are most comfortable with. This may be done by asking several questions of yourself, like "Will I be able to carry out a search in this area? Will I find all necessary resources to accomplish the search? Will I be able to find all information in this field area?" If the answer to this type of question is "yes," then you ought to choose that topic. In most cases, you may have to conduct surveys and visit several places. Also, you might have to do a lot of work to find all the rises and falls of the various data on that subject. Sometimes, detailed information plays a vital role, instead of short information. Evaluators are human: The first thing to remember is that evaluators are also human beings. They are not only meant for rejecting a paper. They are here to evaluate your paper. So present your best aspect.

**2. Think like evaluators:** If you are in confusion or getting demotivated because your paper may not be accepted by the evaluators, then think, and try to evaluate your paper like an evaluator. Try to understand what an evaluator wants in your research paper, and you will automatically have your answer. Make blueprints of paper: The outline is the plan or framework that will help you to arrange your thoughts. It will make your paper logical. But remember that all points of your outline must be related to the topic you have chosen.

**3. Ask your guides:** If you are having any difficulty with your research, then do not hesitate to share your difficulty with your guide (if you have one). They will surely help you out and resolve your doubts. If you can't clarify what exactly you require for your work, then ask your supervisor to help you with an alternative. He or she might also provide you with a list of essential readings.

**4. Use of computer is recommended:** As you are doing research in the field of research engineering then this point is quite obvious. Use right software: Always use good quality software packages. If you are not capable of judging good software, then you can lose the quality of your paper unknowingly. There are various programs available to help you which you can get through the internet.

**5. Use the internet for help:** An excellent start for your paper is using Google. It is a wondrous search engine, where you can have your doubts resolved. You may also read some answers for the frequent question of how to write your research paper or find a model research paper. You can download books from the internet. If you have all the required books, place importance on reading, selecting, and analyzing the specified information. Then sketch out your research paper. Use big pictures: You may use encyclopedias like Wikipedia to get pictures with the best resolution. At Global Journals, you should strictly follow [here](#).





**6. Bookmarks are useful:** When you read any book or magazine, you generally use bookmarks, right? It is a good habit which helps to not lose your continuity. You should always use bookmarks while searching on the internet also, which will make your search easier.

**7. Revise what you wrote:** When you write anything, always read it, summarize it, and then finalize it.

**8. Make every effort:** Make every effort to mention what you are going to write in your paper. That means always have a good start. Try to mention everything in the introduction—what is the need for a particular research paper. Polish your work with good writing skills and always give an evaluator what he wants. Make backups: When you are going to do any important thing like making a research paper, you should always have backup copies of it either on your computer or on paper. This protects you from losing any portion of your important data.

**9. Produce good diagrams of your own:** Always try to include good charts or diagrams in your paper to improve quality. Using several unnecessary diagrams will degrade the quality of your paper by creating a hodgepodge. So always try to include diagrams which were made by you to improve the readability of your paper. Use of direct quotes: When you do research relevant to literature, history, or current affairs, then use of quotes becomes essential, but if the study is relevant to science, use of quotes is not preferable.

**10. Use proper verb tense:** Use proper verb tenses in your paper. Use past tense to present those events that have happened. Use present tense to indicate events that are going on. Use future tense to indicate events that will happen in the future. Use of wrong tenses will confuse the evaluator. Avoid sentences that are incomplete.

**11. Pick a good study spot:** Always try to pick a spot for your research which is quiet. Not every spot is good for studying.

**12. Know what you know:** Always try to know what you know by making objectives, otherwise you will be confused and unable to achieve your target.

**13. Use good grammar:** Always use good grammar and words that will have a positive impact on the evaluator; use of good vocabulary does not mean using tough words which the evaluator has to find in a dictionary. Do not fragment sentences. Eliminate one-word sentences. Do not ever use a big word when a smaller one would suffice.

Verbs have to be in agreement with their subjects. In a research paper, do not start sentences with conjunctions or finish them with prepositions. When writing formally, it is advisable to never split an infinitive because someone will (wrongly) complain. Avoid clichés like a disease. Always shun irritating alliteration. Use language which is simple and straightforward. Put together a neat summary.

**14. Arrangement of information:** Each section of the main body should start with an opening sentence, and there should be a changeover at the end of the section. Give only valid and powerful arguments for your topic. You may also maintain your arguments with records.

**15. Never start at the last minute:** Always allow enough time for research work. Leaving everything to the last minute will degrade your paper and spoil your work.

**16. Multitasking in research is not good:** Doing several things at the same time is a bad habit in the case of research activity. Research is an area where everything has a particular time slot. Divide your research work into parts, and do a particular part in a particular time slot.

**17. Never copy others' work:** Never copy others' work and give it your name because if the evaluator has seen it anywhere, you will be in trouble. Take proper rest and food: No matter how many hours you spend on your research activity, if you are not taking care of your health, then all your efforts will have been in vain. For quality research, take proper rest and food.

**18. Go to seminars:** Attend seminars if the topic is relevant to your research area. Utilize all your resources.

**19. Refresh your mind after intervals:** Try to give your mind a rest by listening to soft music or sleeping in intervals. This will also improve your memory. Acquire colleagues: Always try to acquire colleagues. No matter how sharp you are, if you acquire colleagues, they can give you ideas which will be helpful to your research.

**20. Think technically:** Always think technically. If anything happens, search for its reasons, benefits, and demerits. Think and then print: When you go to print your paper, check that tables are not split, headings are not detached from their descriptions, and page sequence is maintained.



**21. Adding unnecessary information:** Do not add unnecessary information like "I have used MS Excel to draw graphs." Irrelevant and inappropriate material is superfluous. Foreign terminology and phrases are not apropos. One should never take a broad view. Analogy is like feathers on a snake. Use words properly, regardless of how others use them. Remove quotations. Puns are for kids, not grunt readers. Never oversimplify: When adding material to your research paper, never go for oversimplification; this will definitely irritate the evaluator. Be specific. Never use rhythmic redundancies. Contractions shouldn't be used in a research paper. Comparisons are as terrible as clichés. Give up ampersands, abbreviations, and so on. Remove commas that are not necessary. Parenthetical words should be between brackets or commas. Understatement is always the best way to put forward earth-shaking thoughts. Give a detailed literary review.

**22. Report concluded results:** Use concluded results. From raw data, filter the results, and then conclude your studies based on measurements and observations taken. An appropriate number of decimal places should be used. Parenthetical remarks are prohibited here. Proofread carefully at the final stage. At the end, give an outline to your arguments. Spot perspectives of further study of the subject. Justify your conclusion at the bottom sufficiently, which will probably include examples.

**23. Upon conclusion:** Once you have concluded your research, the next most important step is to present your findings. Presentation is extremely important as it is the definite medium through which your research is going to be in print for the rest of the crowd. Care should be taken to categorize your thoughts well and present them in a logical and neat manner. A good quality research paper format is essential because it serves to highlight your research paper and bring to light all necessary aspects of your research.

## INFORMAL GUIDELINES OF RESEARCH PAPER WRITING

### Key points to remember:

- Submit all work in its final form.
- Write your paper in the form which is presented in the guidelines using the template.
- Please note the criteria peer reviewers will use for grading the final paper.

### Final points:

One purpose of organizing a research paper is to let people interpret your efforts selectively. The journal requires the following sections, submitted in the order listed, with each section starting on a new page:

*The introduction:* This will be compiled from reference matter and reflect the design processes or outline of basis that directed you to make a study. As you carry out the process of study, the method and process section will be constructed like that. The results segment will show related statistics in nearly sequential order and direct reviewers to similar intellectual paths throughout the data that you gathered to carry out your study.

### The discussion section:

This will provide understanding of the data and projections as to the implications of the results. The use of good quality references throughout the paper will give the effort trustworthiness by representing an alertness to prior workings.

Writing a research paper is not an easy job, no matter how trouble-free the actual research or concept. Practice, excellent preparation, and controlled record-keeping are the only means to make straightforward progression.

### General style:

Specific editorial column necessities for compliance of a manuscript will always take over from directions in these general guidelines.

**To make a paper clear:** Adhere to recommended page limits.

### Mistakes to avoid:

- Insertion of a title at the foot of a page with subsequent text on the next page.
- Separating a table, chart, or figure—confine each to a single page.
- Submitting a manuscript with pages out of sequence.
- In every section of your document, use standard writing style, including articles ("a" and "the").
- Keep paying attention to the topic of the paper.



- Use paragraphs to split each significant point (excluding the abstract).
- Align the primary line of each section.
- Present your points in sound order.
- Use present tense to report well-accepted matters.
- Use past tense to describe specific results.
- Do not use familiar wording; don't address the reviewer directly. Don't use slang or superlatives.
- Avoid use of extra pictures—include only those figures essential to presenting results.

#### **Title page:**

Choose a revealing title. It should be short and include the name(s) and address(es) of all authors. It should not have acronyms or abbreviations or exceed two printed lines.

**Abstract:** This summary should be two hundred words or less. It should clearly and briefly explain the key findings reported in the manuscript and must have precise statistics. It should not have acronyms or abbreviations. It should be logical in itself. Do not cite references at this point.

An abstract is a brief, distinct paragraph summary of finished work or work in development. In a minute or less, a reviewer can be taught the foundation behind the study, common approaches to the problem, relevant results, and significant conclusions or new questions.

Write your summary when your paper is completed because how can you write the summary of anything which is not yet written? Wealth of terminology is very essential in abstract. Use comprehensive sentences, and do not sacrifice readability for brevity; you can maintain it succinctly by phrasing sentences so that they provide more than a lone rationale. The author can at this moment go straight to shortening the outcome. Sum up the study with the subsequent elements in any summary. Try to limit the initial two items to no more than one line each.

*Reason for writing the article—theory, overall issue, purpose.*

- Fundamental goal.
- To-the-point depiction of the research.
- Consequences, including definite statistics—if the consequences are quantitative in nature, account for this; results of any numerical analysis should be reported. Significant conclusions or questions that emerge from the research.

#### **Approach:**

- Single section and succinct.
- An outline of the job done is always written in past tense.
- Concentrate on shortening results—limit background information to a verdict or two.
- Exact spelling, clarity of sentences and phrases, and appropriate reporting of quantities (proper units, important statistics) are just as significant in an abstract as they are anywhere else.

#### **Introduction:**

The introduction should "introduce" the manuscript. The reviewer should be presented with sufficient background information to be capable of comprehending and calculating the purpose of your study without having to refer to other works. The basis for the study should be offered. Give the most important references, but avoid making a comprehensive appraisal of the topic. Describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will give no attention to your results. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here.

*The following approach can create a valuable beginning:*

- Explain the value (significance) of the study.
- Defend the model—why did you employ this particular system or method? What is its compensation? Remark upon its appropriateness from an abstract point of view as well as pointing out sensible reasons for using it.
- Present a justification. State your particular theory(-ies) or aim(s), and describe the logic that led you to choose them.
- Briefly explain the study's tentative purpose and how it meets the declared objectives.



**Approach:**

Use past tense except for when referring to recognized facts. After all, the manuscript will be submitted after the entire job is done. Sort out your thoughts; manufacture one key point for every section. If you make the four points listed above, you will need at least four paragraphs. Present surrounding information only when it is necessary to support a situation. The reviewer does not desire to read everything you know about a topic. Shape the theory specifically—do not take a broad view.

As always, give awareness to spelling, simplicity, and correctness of sentences and phrases.

**Procedures (methods and materials):**

This part is supposed to be the easiest to carve if you have good skills. A soundly written procedures segment allows a capable scientist to replicate your results. Present precise information about your supplies. The suppliers and clarity of reagents can be helpful bits of information. Present methods in sequential order, but linked methodologies can be grouped as a segment. Be concise when relating the protocols. Attempt to give the least amount of information that would permit another capable scientist to replicate your outcome, but be cautious that vital information is integrated. The use of subheadings is suggested and ought to be synchronized with the results section.

When a technique is used that has been well-described in another section, mention the specific item describing the way, but draw the basic principle while stating the situation. The purpose is to show all particular resources and broad procedures so that another person may use some or all of the methods in one more study or referee the scientific value of your work. It is not to be a step-by-step report of the whole thing you did, nor is a methods section a set of orders.

**Materials:**

*Materials may be reported in part of a section or else they may be recognized along with your measures.*

**Methods:**

- Report the method and not the particulars of each process that engaged the same methodology.
- Describe the method entirely.
- To be succinct, present methods under headings dedicated to specific dealings or groups of measures.
- Simplify—detail how procedures were completed, not how they were performed on a particular day.
- If well-known procedures were used, account for the procedure by name, possibly with a reference, and that's all.

**Approach:**

It is embarrassing to use vigorous voice when documenting methods without using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result, when writing up the methods, most authors use third person passive voice.

Use standard style in this and every other part of the paper—avoid familiar lists, and use full sentences.

**What to keep away from:**

- Resources and methods are not a set of information.
- Skip all descriptive information and surroundings—save it for the argument.
- Leave out information that is immaterial to a third party.

**Results:**

The principle of a results segment is to present and demonstrate your conclusion. Create this part as entirely objective details of the outcome, and save all understanding for the discussion.

The page length of this segment is set by the sum and types of data to be reported. Use statistics and tables, if suitable, to present consequences most efficiently.

You must clearly differentiate material which would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matters should not be submitted at all except if requested by the instructor.



**Content:**

- Sum up your conclusions in text and demonstrate them, if suitable, with figures and tables.
- In the manuscript, explain each of your consequences, and point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation of an exacting study.
- Explain results of control experiments and give remarks that are not accessible in a prescribed figure or table, if appropriate.
- Examine your data, then prepare the analyzed (transformed) data in the form of a figure (graph), table, or manuscript.

**What to stay away from:**

- Do not discuss or infer your outcome, report surrounding information, or try to explain anything.
- Do not include raw data or intermediate calculations in a research manuscript.
- Do not present similar data more than once.
- A manuscript should complement any figures or tables, not duplicate information.
- Never confuse figures with tables—there is a difference.

**Approach:**

As always, use past tense when you submit your results, and put the whole thing in a reasonable order.

Put figures and tables, appropriately numbered, in order at the end of the report.

If you desire, you may place your figures and tables properly within the text of your results section.

**Figures and tables:**

If you put figures and tables at the end of some details, make certain that they are visibly distinguished from any attached appendix materials, such as raw facts. Whatever the position, each table must be titled, numbered one after the other, and include a heading. All figures and tables must be divided from the text.

**Discussion:**

The discussion is expected to be the trickiest segment to write. A lot of papers submitted to the journal are discarded based on problems with the discussion. There is no rule for how long an argument should be.

Position your understanding of the outcome visibly to lead the reviewer through your conclusions, and then finish the paper with a summing up of the implications of the study. The purpose here is to offer an understanding of your results and support all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of results should be fully described.

Infer your data in the conversation in suitable depth. This means that when you clarify an observable fact, you must explain mechanisms that may account for the observation. If your results vary from your prospect, make clear why that may have happened. If your results agree, then explain the theory that the proof supported. It is never suitable to just state that the data approved the prospect, and let it drop at that. Make a decision as to whether each premise is supported or discarded or if you cannot make a conclusion with assurance. Do not just dismiss a study or part of a study as "uncertain."

Research papers are not acknowledged if the work is imperfect. Draw what conclusions you can based upon the results that you have, and take care of the study as a finished work.

- You may propose future guidelines, such as how an experiment might be personalized to accomplish a new idea.
- Give details of all of your remarks as much as possible, focusing on mechanisms.
- Make a decision as to whether the tentative design sufficiently addressed the theory and whether or not it was correctly restricted. Try to present substitute explanations if they are sensible alternatives.
- One piece of research will not counter an overall question, so maintain the large picture in mind. Where do you go next? The best studies unlock new avenues of study. What questions remain?
- Recommendations for detailed papers will offer supplementary suggestions.



**Approach:**

When you refer to information, differentiate data generated by your own studies from other available information. Present work done by specific persons (including you) in past tense.

Describe generally acknowledged facts and main beliefs in present tense.

## THE ADMINISTRATION RULES

Administration Rules to Be Strictly Followed before Submitting Your Research Paper to Global Journals Inc.

*Please read the following rules and regulations carefully before submitting your research paper to Global Journals Inc. to avoid rejection.*

*Segment draft and final research paper:* You have to strictly follow the template of a research paper, failing which your paper may get rejected. You are expected to write each part of the paper wholly on your own. The peer reviewers need to identify your own perspective of the concepts in your own terms. Please do not extract straight from any other source, and do not rephrase someone else's analysis. Do not allow anyone else to proofread your manuscript.

*Written material:* You may discuss this with your guides and key sources. Do not copy anyone else's paper, even if this is only imitation, otherwise it will be rejected on the grounds of plagiarism, which is illegal. Various methods to avoid plagiarism are strictly applied by us to every paper, and, if found guilty, you may be blacklisted, which could affect your career adversely. To guard yourself and others from possible illegal use, please do not permit anyone to use or even read your paper and file.





CRITERION FOR GRADING A RESEARCH PAPER (COMPILATION)  
BY GLOBAL JOURNALS

Please note that following table is only a Grading of "Paper Compilation" and not on "Performed/Stated Research" whose grading solely depends on Individual Assigned Peer Reviewer and Editorial Board Member. These can be available only on request and after decision of Paper. This report will be the property of Global Journals.

| Topics                        | Grades   |   |  |
|-------------------------------|--|---|--|
|                               | A-B  | C-D   | E-F  |
| <i>Abstract</i>               | Clear and concise with appropriate content, Correct format. 200 words or below   | Unclear summary and no specific data, Incorrect form<br>Above 200 words                             | No specific data with ambiguous information<br>Above 250 words |
| <i>Introduction</i>           | Containing all background details with clear goal and appropriate details, flow specification, no grammar and spelling mistake, well organized sentence and paragraph, reference cited | Unclear and confusing data, appropriate format, grammar and spelling errors with unorganized matter | Out of place depth and content, hazy format                    |
| <i>Methods and Procedures</i> | Clear and to the point with well arranged paragraph, precision and accuracy of facts and figures, well organized subheads  | Difficult to comprehend with embarrassed text, too much explanation but completed                   | Incorrect and unorganized structure with hazy meaning          |
| <i>Result</i>                 | Well organized, Clear and specific, Correct units with precision, correct data, well structuring of paragraph, no grammar and spelling mistake   | Complete and embarrassed text, difficult to comprehend  | Irregular format with wrong facts and figures                  |
| <i>Discussion</i>             | Well organized, meaningful specification, sound conclusion, logical and concise explanation, highly structured paragraph reference cited   | Wordy, unclear conclusion, spurious   | Conclusion is not cited, unorganized, difficult to comprehend  |
| <i>References</i>             | Complete and correct format, well organized  | Beside the point, Incomplete  | Wrong format and structuring                                   |



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