World Essays Journal / 10 (4): 118-124, 2022
Available online at www. worldessaysj.com
ISSN online: 2310-1377, Print: 2310-8509

Desenvolvimento e Avaliação de Desempenho de Máquina Automatizada para Ralar Mandioca

Abudu Muhammed[1], Ososomi Sunday[1], Omoakhalen A.I[1], Imuran A.S[2]

1. Department of Mechanical Engineering, Auchi Polytechnic, Auchi, Nigeria
2. Department of Mechanical Engineering, Federal Polytechnic, Offa, Nigeria
Corresponding Author email: mmabdul53@yahoo.com

Paper Information

Received: 14 August, 2022

Accepted: 27 November, 2022

Published: 20 February, 2022

A B S T R A C T

Performance and economic returns of developed automated cassava-grating machine was investigated. The equipment has a realistic functional efficiency of 91.5% and 88.4% for manually and electrically powered operation with the discharge capacity 4.04 and 3.66 tons per day respectively. Simulation of its economic analysis shows between $2.6 and $3.0 could be saved while using automated cassava grater over manual system for 1-ton of cassava tuber. At 0.01 and 0.05 level of significance, it showed that the machine has a good economic potential over the convection method of grating. It saves time and labour requirements by a factor of 0.68. Design of a Cassava grating machine is dual-mode in operation; it is powered both manually and mechanically. This feature makes it useful in the rural areas where there is erratic or no power supply. Cassava is fed into machine through the hopper down to the granting drum, which rotates at a pre-set constant speed. Cassava is an important starchy root crop of the tropical world, the need to mechanize its growing and processing cannot be overemphasised.

© 2020 WEJ Publisher All rights reserved.

Key words: *Cassava, Grating, Convectional, Efficiency, Economic, Potential, Ton, Discharge, grating machine, Powered, hopper*

This work is licensed under the Creative Commons Attribution 4.0 International License. To view a copy of this license, visit http://creativecommons.org/licenses/by/4.0/.

Introduction

Cassava (Manihot esculenta Crantz) is a very important crop in Nigeria deriving from the extensive use of the various products and by-products as staples to most Nigerians. The consumption of cassava cuts across all parts of the country. It is a major source of carbohydrates in human diet, being processed into Garri, fatal and typical as a constituent for human food. Recently other areas of uses of cassava are being implored. It is also being used as starch [Adegeye, 1985]. The crop tolerance makes it more popular and now replacing yam in some part of Nigeria. The sweet varieties could be boiled for human consumption. Its adaptability to climatic and soil conditions even in marginal soils has endeared cassava to most people that have to do continuous cultivation on limited available land. Cassava is a shrubby, tropical, perennial plant that is not well known in the temperate zone. For most people, cassava is most commonly associated with tapioca. The plant grows tall, sometime reaching 15 feet, with leaves varying in shape and size. The edible parts are tuberous root and leaves. The tuber (root) is somewhat dark brown in color and grows up to 2 feet long. Cassava (manihot esculenta), has its origin as South America, presumably Eastern Brazil. It thrives better in poor soils them any other major food plants.

Nigeria has been world-leading producer of cassava with an estimated annual production of 2.6 million tons from an estimated area of 1% million hectares of land [Agbetoye, 2005] and [CBN, 1994]. The major problem of cassava is that it is extremely perishable and the harvested tuber must be process to curb post-harvest losses [Davies, 1991]. According to food and Agriculture Organization [5] the estimated industrial cassava use was approximately, 16 percent of cassava root production and was utilized as an industrial raw material in 2001 in Nigeria. Around the world, cassava is a vital stable for about 500 million people. Cassava's starching roots produce more food energy permit of land than any other staple crop.

Nigeria is currently the largest cassava producer in the world with estimated annual production of about 40 million metric tons. About 90% of this is however, consumed as food. The country is yet to fully harness the socio-economic potential of cassava that world translate to higher ranking of cassava next to petroleum as major contributor to the Goss Domestic Product (GDP). However, the need to mechanize cassava processing is enormous. The convectional cassava processing has a number of disadvantages and requires human energy and time and this has necessitated the design and development of mechanically-operated cassava grating machine. It was revealed that cassava peeling is still largely done manually; however, women and teenage girls are normally involved in the manual peeling of the tuber [Eagleston,1992]. The rate could be as high as 350 kg/day of 8 hour/person [Eagleston, 1992]. The process is slow and labour intensive which invariably leads to low productivity. [FAO, 2007] reported that some essential tuber properties such as group average diameter, penetration force per unit length and peel thickness should be determined in order to design an efficient mechanical peeling system. Olukunle and Adesina (2004) reported that the maximum machine capacity was 1000 kg/h. Mechanized cassava grater has been a point of focus for the research as far back as 1960 and effort at improving grating efficiency and mode of operation are still on going. Therefore, the research study is focused on generating design-based output and carrying out performance evaluation on the mechanical cassava grating in order to improve on its functional efficiency for maximum optimization.

Materials and Methods

Design Considerations

The general consideration in designing grating machine is to create rubost functional efficiency which the machine can easily be operated, transported, assembled and dissembled machine. Each of the component parts such as hopper, grating drum and others were fabricated with high quality materials which cannot easily corrode or worn-out. Design expressions for the following component parts are as follows:

Hopper:

The Volume of which was obtained as follow:

$$V = L \cdot B \cdot H \ (m^3) \quad (1)$$

Where V = Volume of the hopper, L = Hopper's length, B = Hopper's breath, and H = Hopper's height.

The mass of Hopper is given as:

$$M = \rho \cdot V \ (kg) \quad (2)$$

where ρ = density of material[1]

Shaft design

For solid shaft having little or no axial load, the diameter is given by:

$$d^3 = 16/\pi S_s \left((K_b M_b)^2 + (K_t M_t)^2\right)^{1/2} \quad (2)$$

Where M_t = torsional moment, M_b = bending moment, K_b = combined shock and fatigue applied to bending moment (1.5), K_t = combine shock & fatigue applied to torsional moment (1.0), and S_s = allowable stress. For a shaft transmitting power (kW) at a rotational speed (rpm) the transmitting torque is given as:

$$M_t = Power/Speed \quad (3)$$

The speed ratio of the larger pulley on the machine shaft to the smaller pulley on the electric motor is givens as:

$$N_1 D_1 = N_2 D_2 \quad (4)$$

Where N_1 = speed of electric motor, N_2 = speed of machine driving shaft, D_1 = diameter of motor pulley, and D_2 = diameter of machine drive pulley.

Performance evaluation of the machine

Cassava tuber was fed into the hopper one by one and the results were evaluated for each pass. The machine operational parameters such as throughput capacity, peeling efficiency, mechanical damage, quality performance efficiency and peel retention were determined using the following expressions [8].

Grater efficiency

The machine was designed to accommodate a maximum of 4 tubers of 1.1kg each in its hopper. The functional capacity of the hopper is 5.0 kg.

Therefore, the functional efficiency of the machine is expressed as follows:

$$GFE = \frac{CPOG}{LCTG} * 100 \quad (5)$$

Where;

CPOG = Cassava pulp output from the grating machine

LCTG = Loaded cassava tuber from the grating machine

Machine capacity

The discharge rate of the machine is determined using the expression in equation (2) as follows:

$$QRM = \frac{TNT}{Tt} \left(\frac{kg}{\min}\right) \quad \textbf{(6)}$$

Where;
QRM = Discharge rate of the machine (Kg/min)
TNT = Total number of tubers (Kg)
Tt = Time taken (min)

The machine capacity is estimated using the relationship in equation (3):

$$MC = QM \qquad (7)$$

Where;
MC is the machine capacity (Kg/hr)
Q is the discharge rate
M is the mass of cassava tuber.

Throughput capacity Tc (kg/h) :

$$\frac{W}{T}$$

Where Wt = Weight of cassava fed into the machine
(kg) and T = Time taken for the cassava and its peel to completely leave the machine (h) [8]

$$P = \frac{Mpc}{Ms} \qquad (8)$$

Where P is the proportion by weight of peel Mpc is the weight of peel collected and Ms is the weight of sample Plate 1 and fig,1 show developed cassava grating machine during operation and its component specification.

Table 1: Machine specification

Capacity:	449kg/hour
Mode:	5.5 HP Petrol Engine or Electric
Feature:	Production of fine marsh suitable for the production of high quality cassava flour and starch grain. Robust, Portable machine. Ease of maintenance and operation. Economy of operation.

Economic evaluation

The economic evaluation of using the cassava-grating machine was evaluated as follows: The service capacity per day is evaluated as follows:

$$SCD = 0.001Q \qquad (9)$$

Where,
SCD = Service capacity/day
Q = Discharge rate
Factor 0.001 = Working hour (9hrs.) per day
Therefore, the machine service capacity per year is evaluated as follows:

$$SCY = 0.43Q \qquad (10)$$

Where,
SCD = Service capacity/year;
Factor 0.43 = Working hour (9hrs.) per day for 365-day.

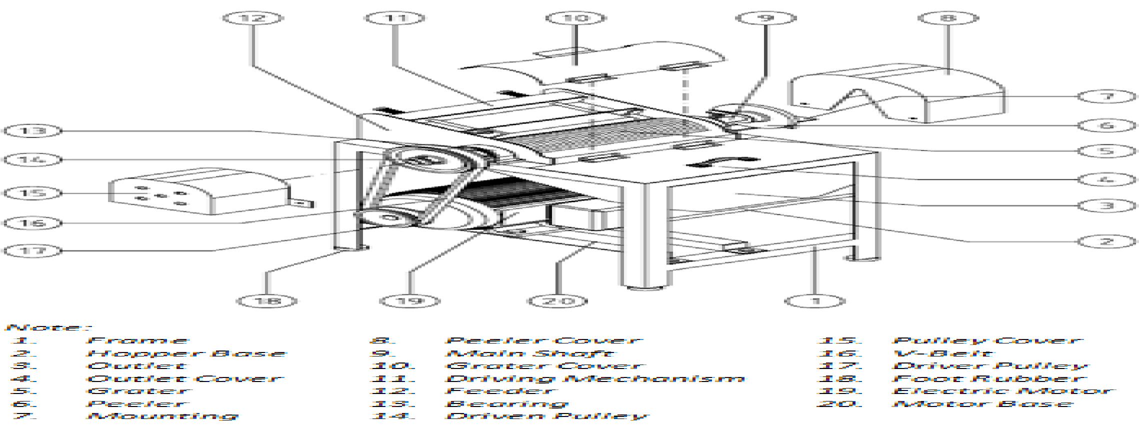

Figure1: Component parts of grating machine

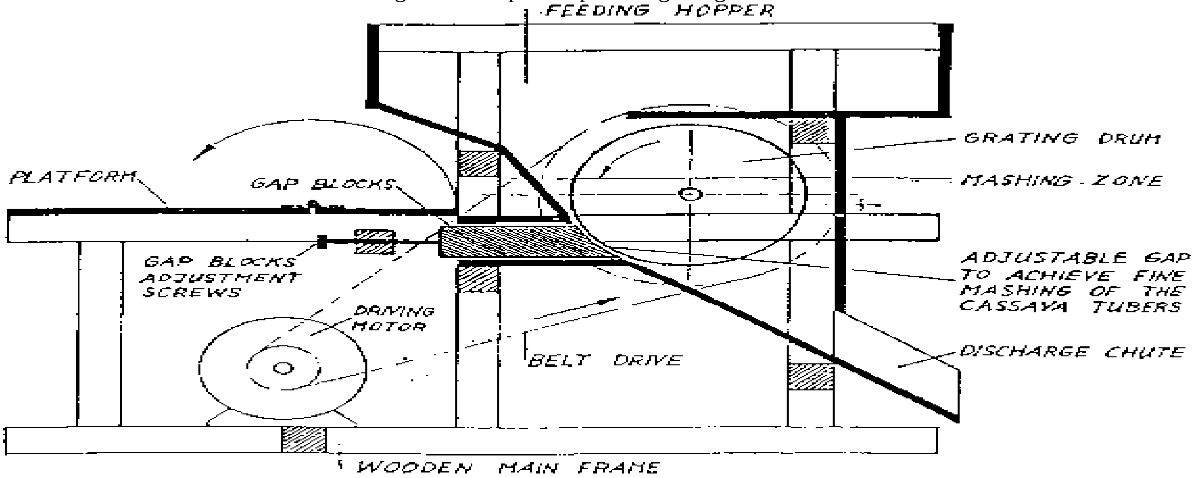

Figure 2: Section through of cassava grater

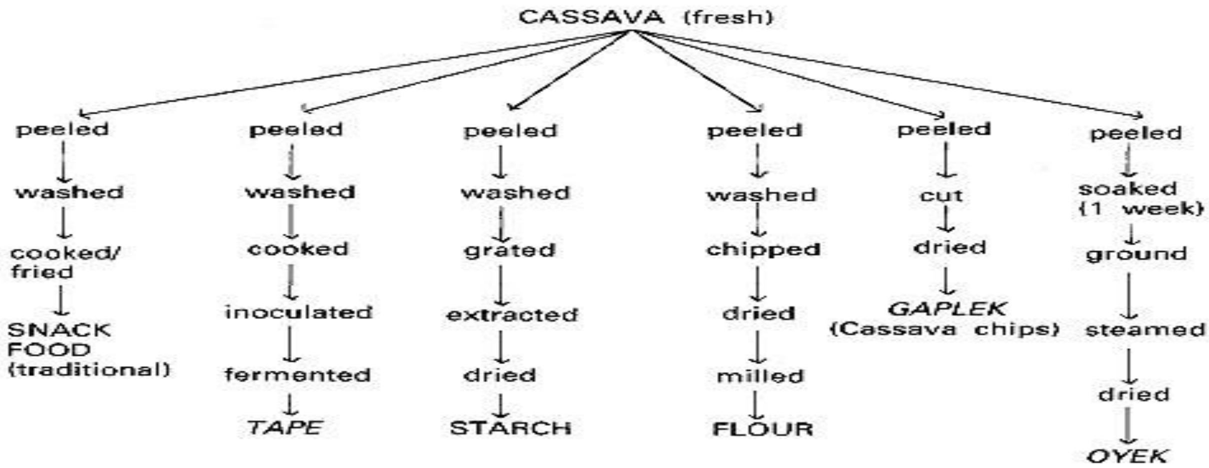

Figure 3: Different cassava processings

Plate.1: Cassava grater during operation

Result and discussion

Materials selection and cost

Creating equipment that perform their function effectively, safely, at acceptable cost must be well structured. The set of properties for a particular material is called the "material attributes" which includes both structured and nonstructured information on the material –materials selection involves seeking the best match between the design requirements and the materials attributes. Materials were selected based on the function each of the components was designed to perform. The specification and cost of each selected component is shown in below:

Table.2: Material selection

S/N	Qty	Description	Size	Amount ($)
1	1	Galvanized steel 2mm	750 x 2250	12
2	1	Metal shaft	30 x 500mm	15
3	1	Wood	250 x 400mm	9.2
4	2	2 inches angle bar	2mm x 2mm	9.0
5	2	Bearings(pillow block)	6207	13.4
6	2	Bearing cases		11.0
7	1 packet	Electrodes	G12	6.5
8	1	Cutting disc		10.0
9	1	Grater		9.5
10	40	Nails	3	2.5
11	12	Bolts and Nuts	M16	2.5
12	1	Electric motor	220-420v	74
13	2	Pulley		15.5
14	2	Sand paper		2.5
15	1	Wooden plank	2 x 12 ft	6
16	1	Flat belt		5.5
17		Miscellaneous		5.5
			Total	28,750

Source: Field study, 2008

Analysis and evaluation of cassava grating cost

Production cost

The production cost of the machine is the sum of the total material cost, labour, and transportation/handling cost. The three cost variables are mathematically related in equation (4) as follows:

$$PCM = (tMc + tLc + tTc)\boldsymbol{\mu} \tag{12}$$

Where,

PCM = Production cost of the machine

tMc = Total cost of materials

tT = cost of transportation/materials handling

$\boldsymbol{\mu}$ = cost index (0.99)

Materials selection is a central aspect of design. Converting selected materials to developed cassava grating machine, some input expenses on the part of human operation and component machinery cost would have been expended. Table 3 shows the cost analysis

Table 3: Cost analysis

S/N	Description	Amount($)
1	Cutting, welding and nailing	100
2	Machining	120
3	Assembling	140
	Total	**360**

Source: Field study, 2008

Cassava tubers of varying sizes were used for experimental operation. Table 4 shows various weights of the cassava tuber used for the simulation. Table 5 shows the output of cassava grating machine using various number, size and weight of cassava tuber.

Table 4: Weight of cassava

S/N	Mass of Tuber (KG)
1	1.4
2	1.78
3	1.20
4	1.60
5	1.00
6	0.89
7	1.48
Total	9.35

Source: Field study, 2008

Table 5: Output of cassava grating machine

S/N	NTP	TG(s)	MGCT
1	1	11	1.40
2	2	12	1.78
3	1	10	1.20
4	2	12	1.60
5	1	0.9	1.00
6	1	10	8.89
7	2	11	1.48
Total	13	75.5	9.35kg

Source: Field study, 2008

Note: NTP = No of cassava tuber TG = Grating time (s) MGCT = Mass of grated cassava tuber

The output from the table 4 above shows that 13 tubers of cassava were grated within 76 seconds. The results revealed that as the speed of the machine increased from 120 – 550 rpm, throughput capacity increased from 70 – 146 kg/h depending on the size and weight of cassava.

Mechanical damage increased as the speed of the machine increased.

Conclusion

The functional efficiency and economic returns of cassava grating machine were evaluated using different technical-based techniques. It was deduced that the equipment has a grating and working capacity of 509 kg/hr of cassava tuber to pulp and 10-hour per day as operation period. It shows that the instrument grates 5,041(4.04 tons) kg/day and 1,857,8504kg (1857.85 tons) per year respectively. Automated cassava grating machine greatly reduces drudgery and saves time over the conventional method of grating. In addition operation cost of $2.6 is being saved over the convectional system for grating 1-ton of cassava tuber. The equipment is very easy to operate and the maintenance is very low because of its indigenous technological-based and has realistic functional efficiency of 90.5%. In view of this, the machine is recommended for both farmers and cassava-based manufacturing industries for higher grating efficiency.

References

Abdein, Amna Abdelmoneim Elsayied. "Flood Impact Assessment Using Hec-Ras and Gis Techniques Dinder River, Southeast Sudan." *Water and Environmental Sustainability* 1.3 (2021): 14-19. Print.

Abdolhakim, Islam. "Assessing the Overwhelming Metals in Roadside Soils of Fundamental Roads in Jos City, Nigeria." *Water and Environmental Sustainability* 1.3 (2021): 1-6. Print.

Achebe, Kingsley Mohammed, and Olagunju. "Employing Spider Webs for Environmental Investigation of Suspended Trace Metals in Residential and Industrial Areas." *Water and Environmental Sustainability* 1.4 (2021): 22-26. Print.

Alaei, Moslem, et al. "Evaluation of Germination Properties of Different Durum Wheat Genotypes under Osmotic Stress." *Middle-East J. Sci. Res* 6.6 (2010): 642-46. Print.

Alerto, Saviour. "Occurring the Paraquat Residues in Various Nigerian." *Water and Environmental Sustainability* 3.1 (2021): 29-32. Print.

Aletor, Saviour. "Environmentally Induced Alternative Livelihood Strategies among the Artisanal Fishers of the Kainji Lake Basin, Nigeria." *Water and Environmental Sustainability* 1.1 (2021): 1-7. Print.

Barth, Oliver. "The Effect of Supplemental Instruction on Educational Accomplishments and Behaviors of Organic Chemistry Scholars." *Water and Environmental Sustainability* 1.1 (2021): 30-36. Print.

Baruah, Sanji. "Assessing Heavy Metal Bioaccumulation in Freshwater Fish at the Gingee River in Puducherry, India." *Water and Environmental Sustainability* 1.4 (2021): 1-4. Print.

Bi, Dezhong, et al. "Molecular Identification and Genetic Diversity in Hypericum L.: A High Value Medicinal Plant Using Rapd Markers Markers." *Genetika* 53.1 (2021): 393-405. Print.

Cheng, Xiao, et al. "Genetic Diversity and Comparative Study of Genomic DNA Extraction Protocols in Tamarix L. Species." *Caryologia* 74.2 (2021): 131-39. Print.

Elsayied Abdein, A. A. "The Efficiency of Nitrogen Utilization and Root Nodules' Life Cycle in Alfalfa after Various Mineral Fertilization and Cultivation of Soil." *Water and Environmental Sustainability* 2.4 (2022): 13-20. Print.

Gholamin, Roza, and Majid Khayatnezhad. "Assessment of the Correlation between Chlorophyll Content and Drought Resistance in Corn Cultivars (Zea Mays)." *Helix-The Scientific Explorer| Peer Reviewed Bimonthly International Journal* 10.05 (2020): 93-97. Print.

---. "Study of Bread Wheat Genotype Physiological and Biochemical Responses to Drought Stress." *Helix* 10.5 (2020): 87-92. Print.

---. "The Study of Path Analysis for Durum Wheat (Triticum Durum Desf.) Yield Components." *Bioscience Biotechnology Research Communications* 13.4 (2020): 2139-44. Print.

Gholamin, Roza, et al. "Effects of Polyethylene Glycol and Nacl Stress on Two Cultivars of Wheat (Triticum Durum) at Germination and Early Seeding Stages." *Am Eurasian J Agric Environ Sci* 9.1 (2010): 86-90. Print.

Guo, Haibing, et al. "Parameter Extraction of the Sofc Mathematical Model Based on Fractional Order Version of Dragonfly Algorithm." *International Journal of Hydrogen Energy* 47.57 (2022): 24059-68. Print.

Hewitt, Erica. "Ecological Plunging and Wireless Filming for Science Education: A New Zealand Pilot Experimeent." *Water and Environmental Sustainability* 1.1 (2021): 24-29. Print.

Jamaati-e-Somarin, Shahzad, et al. "Study of Agronomical Nitrogen Use Efficency of Durum Wheat, Affected by Nitrogen Fertilizer and Plant Density." *World Applied Sciences Journal* 11.6 (2010): 674-81. Print.

K. Kabir, S.M.A. Arefin, and M. T. Hosain. "Analysis of Momentary Variations in the Quality of Water on Specific Criteria in Cole Mere." *Water and Environmental Sustainability* 1.1 (2021): 8-12. Print.

Karasakal A, Talib N. "Cadmium Ions Removal Analysis from Wastewater Utilizing Salvadora Persica Stem's Activated Carbon." *Water and Environmental Sustainability* 2.2 (2022): 1-5. Print.

Karasakal, Arda, Majid Khayatnezhad, and Roza Gholamin. "The Durum Wheat Gene Sequence Response Assessment of Triticum Durum for Dehydration Situations Utilizing Different Indicators of Water Deficiency." *Bioscience Biotechnology Research Communications* 13.4 (2020): 2050-57. Print.

---. "The Effect of Saline, Drought, and Presowing Salt Stress on Nitrate Reductase Activity in Varieties of Eleusine Coracana (Gaertn)." *Bioscience Biotechnology Research Communications* 13.4 (2020): 2087-91. Print.

Khayatnezhad, M, M Zaeifizadeh, and R Gholamin. "Investigation and Selection Index for Drought Stress." *Australian Journal of Basic and Applied Sciences* 4.10 (2010): 4815-22. Print.

Khayatnezhad, Majid, and Roza Gholamin. "The Effect of Drought Stress on the Superoxide Dismutase and Chlorophyll Content in Durum Wheat Genotypes." *Advancements in Life Sciences* 8.2 (2021): 119-23. Print.

---. "Effects of Water and Salt Stresses on Germination and Seedling Growth in Two Durum Wheat (Triticum Durum Desf.) Genotypes." *Scientific Research and Essays* 6.21 (2011): 4597-603. Print.

---. "A Modern Equation for Determining the Dry-Spell Resistance of Crops to Identify Suitable Seeds for the Breeding Program Using Modified Stress Tolerance Index (Msti)." *Bioscience Biotechnology Research Communications* 13.4 (2020): 2114-17. Print.

---. "Study of Durum Wheat Genotypes' Response to Drought Stress Conditions." *Helix-The Scientific Explorer| Peer Reviewed Bimonthly International Journal* 10.05 (2020): 98-103. Print.

Khayatnezhad, Majid, et al. "Study of Nacl Salinity Effect on Wheat (Triticum Aestivum L.) Cultivars at Germination Stage." *Am. Eurasian J. Agric. Environ. Sci* 9.2 (2010): 128-32. Print.

Khayatnezhad, Majid, and Fatemeh Nasehi. "Industrial Pesticides and a Methods Assessment for the Reduction of Associated Risks: A Review." *Advancements in Life Sciences* 8.2 (2021): 202-10. Print.

Khayatnezhad, Majid, Mohammad Zaeifizadeh, and Roza Gholamin. "Effect of End-Season Drought Stress on Chlorophyll Fluorescence and Content of Antioxidant Enzyme Superoxide Dismutase Enzyme (Sod) in Susceptible and Tolerant Genotypes of Durum Wheat." *African Journal of Agricultural Research* 6.30 (2011): 6397-406. Print.

Khayatnezhad, Roza Gholamin, and Majid. "The Effect of Dry Season Stretch on Chlorophyll Content and Rwc of Wheat Genotypes (Triticum Durum L.)." *Bioscience Biotechnology Research Communications* 13.4 (2020): 1829-33. Print.

Lin*, Haitao. "Levafix Blue Color's Visible Light Degradation Utilizing Fenton and Photo-Fenton Procedures." *Water and Environmental Sustainability* 2.4 (2022): 1-8. Print.

Ma, Shuyan, Majid Khayatnezhad, and Amir Abbas Minaeifar. "Genetic Diversity and Relationships among Hypericum L. Species by Issr Markers: A High Value Medicinal Plant from Northern of Iran." *Caryologia* 74.1 (2021): 97-107. Print.

Mobar, S, and Bhatnagar. "Ling Women by Greenhouse Plan as Illustrated in the Post-Feminist Tamil Film 36 Vayadhinile." *Water and Environmental Sustainability* 2.4 (2022): 9-12. Print.

Mobar, Sanjoli, and Pradeep Bhatnagar. "Evaluation of Atmosphere Air Quality in Hyderabad Urban, India." *Water and Environmental Sustainability* 2.2 (2021): 30-33. Print.

Mollasadeghi, Vahid, et al. "Classifying Bread Wheat Genotypes by Multivariable Statistical Analysis to Achieve High Yield under after Anthesis Drought." *Middle-East J. Sci. Res* 7.2 (2011): 217-20. Print.

Mollasadeghi, Vahid, et al. "Factor Analysis of Wheat Quantitative Traits on Yield under Terminal Drought." *Am. Eur. J. Agric. Environ. Sci* 10.2 (2011): 157-59. Print.

Niya, Kumar S. "Investigation About Water Quality at Madurai, Tamilnadu, India." *Water and Environmental Sustainability* 2.2 (2021): 6-9. Print.

Radmanesh, Masoud. "Evaluation of the Efficient Management of Greenhouses for Healthy Items in the Province of Alborz." *Water and Environmental Sustainability* 1.1 (2021): 20-23. Print.

Rodríguez, Rubén. "The Study of Enzyme-Water Mutualism Theory." *Water and Environmental Sustainability* 1.1 (2021): 44-49. Print.

Si, Xingxing, et al. "Understanding Population Differentiation Using Geographical, Morphological and Genetic Characterization in Erodium Cicunium." *Indian Journal of Genetics*.4 (2020): 459-67. Print.

Sun, Xiaozhou, and Majid Khayatnezhad. "Fuzzy-Probabilistic Modeling the Flood Characteristics Using Bivariate Frequency Analysis and A-Cut Decomposition." *Water Supply* 21.8 (2021): 4391-403. Print.

Tamia, Shyla. "An Investigation into Value of Eutrophication in Hosur Lakes." *Water and Environmental Sustainability* 1.4 (2021): 16-19. Print.

Wan, Gu. "Discussing Climate Change: Pathways, Origins, Significant Subjects and Developed Guidlines According to Research Taken Place in China." *Water and Environmental Sustainability* 1.1 (2021): 13-19. Print.

Wang, Chen, Yizi Shang, and Majid Khayatnezhad. "Fuzzy Stress-Based Modeling for Probabilistic Irrigation Planning Using Copula-Nspso." *Water Resources Management* 35 (2021): 4943-59. Print.

Wang, Shicheng, et al. "An Optimal Configuration for Hybrid Sofc, Gas Turbine, and Proton Exchange Membrane Electrolyzer Using a Developed Aquila Optimizer." *International Journal of Hydrogen Energy* 47.14 (2022): 8943-55. Print.

Zabihi-e-Mahmoodabad, R, et al. "Quantitative and Qualitative Yield of Potato Tuber by Used of Nitrogen Fertilizer and Plant Density." *American-Eurasian Journal of Agricultural and Environmental Science* 9.3 (2010): 310-18. Print.

Zaefizadeh, Mohammad, et al. "Discriminate Analyses of the Osmotic Stress Tolerance of Different Sub-Convars of Durum Wheat During Germination." *Adv. Environ. Biol* 5.1 (2011): 74-81. Print.

Zheng, Ruonan, et al. "Comparative Study and Genetic Diversity in Salvia (Lamiaceae) Using Rapd Molecular Markers." *Caryologia* 74.2 (2021): 45-56. Print.

Zile Huma, Guangsi Lin, Syed Lakhte Hyder. "Promoting Resilience and Health of Urban Citizen through Urban Green Space." *Water and Environmental Sustainability* 1.1 (2021): 37-43. Print.