BUKTI KORESPONDING PENULIS DENGAN
REVIEWER DAN PENGELOLA JURNAL

Procedia Environmental Science, Engineering and Management

JURNAL INTERNASIONAL BEREPUTASI

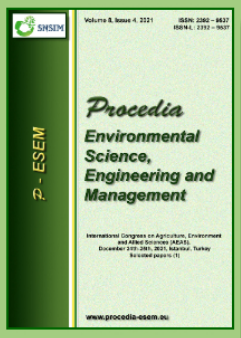
Q3 PADA SCIMAGO JR DAN Q4 PADA SCOPUS

Judul Paper : DESIGN OF INSECT TRAP AUTOMATIC CONTROL SYSTEM FOR CACAO PLANTS

SNSIM
National Society of Environmental Science and Engineering

Procedia
Environmental Science, Engineering and Management

P - ESEM



ISSN: 2392 - 9537
ISSN-L: 2392 - 9537
eISSN: 2392 - 9545

Full cover

Current issue

About

Procedia Environmental Science, Engineering and Management (P - ESEM) is a journal focusing on publishing papers selected from high quality conference proceedings, with emphasis on relevant topics associated to environmental science and engineering, as well as to specific management issues in the area of environmental protection and monitoring.

P - ESEM facilitates rapid dissemination of knowledge in the interdisciplinary area of environmental science, engineering and management, so conference delegates can publish their papers in a dedicated issue. This journal will cover a wide range of related topics, such as: environmental chemistry; environmental biology; ecology geoscience; environmental physics; treatment processes of drinking water and wastewater; contaminant transport and environmental modeling; remediation technologies and biotechnologies; environmental evaluations, law and management; human health and ecological risk assessment; environmental sampling; pollution prevention; pollution control and monitoring etc.

We aim to carry important efforts based on an integrated approach in publishing papers with strong messages addressed to a broad international audience that advance our understanding of environmental principles. For readers, the journal reports generic, topical and innovative experimental and theoretical research on all environmental problems. The papers accepted for publication in P – ESEM are grouped on thematic areas, according to conference topics, and are required to meet certain criteria, in terms of originality and adequacy with journal subject and scope.

Procedia Enviromental Science, Engineering, and Management is covered by:

SCOPUS
EBSCO
INDEX COPERNICUS
GOOGLE SCHOLAR

BUKTI KORESPONDENSI PROCEDIA

Procedia Environmental Science, Engineering and Management

Judul : Design Of Insect Trap Automatic Control System For Cacao Plants

- SUBMIT (27 Maret 2020)
- REVISI 1 (27 Oktober 2020)
- REVISI 2 (29 Oktober 2020)
- TERBIT DI PROCEDIA (Februari 2021)

Daftar Lampiran

Source details

Feedback > Compare sources >

Procedia Environmental Science, Engineering and Management

Scopus coverage years: from 2014 to Present

Publisher: National Society of Environmental Science and Engineering (SNSIM)

ISSN: 2392-9537 E-ISSN: 2392-9545

Subject area: Environmental Science: General Environmental Science

Source type: Journal

View all documents > Set document alert Save to source list

CiteScore 2021
1.0

SJR 2021
0.409

SNIP 2021
0.525

CiteScore CiteScore rank & trend Scopus content coverage

Improved CiteScore methodology

CiteScore 2021 counts the citations received in 2018-2021 to articles, reviews, conference papers, book chapters and data papers published in 2018-2021, and divides this by the number of publications published in 2018-2021. Learn more >

CiteScore 2021

$1.0 = \frac{248 \text{ Citations } 2018 - 2021}{247 \text{ Documents } 2018 - 2021}$

Calculated on 05 May, 2022

CiteScoreTracker 2022

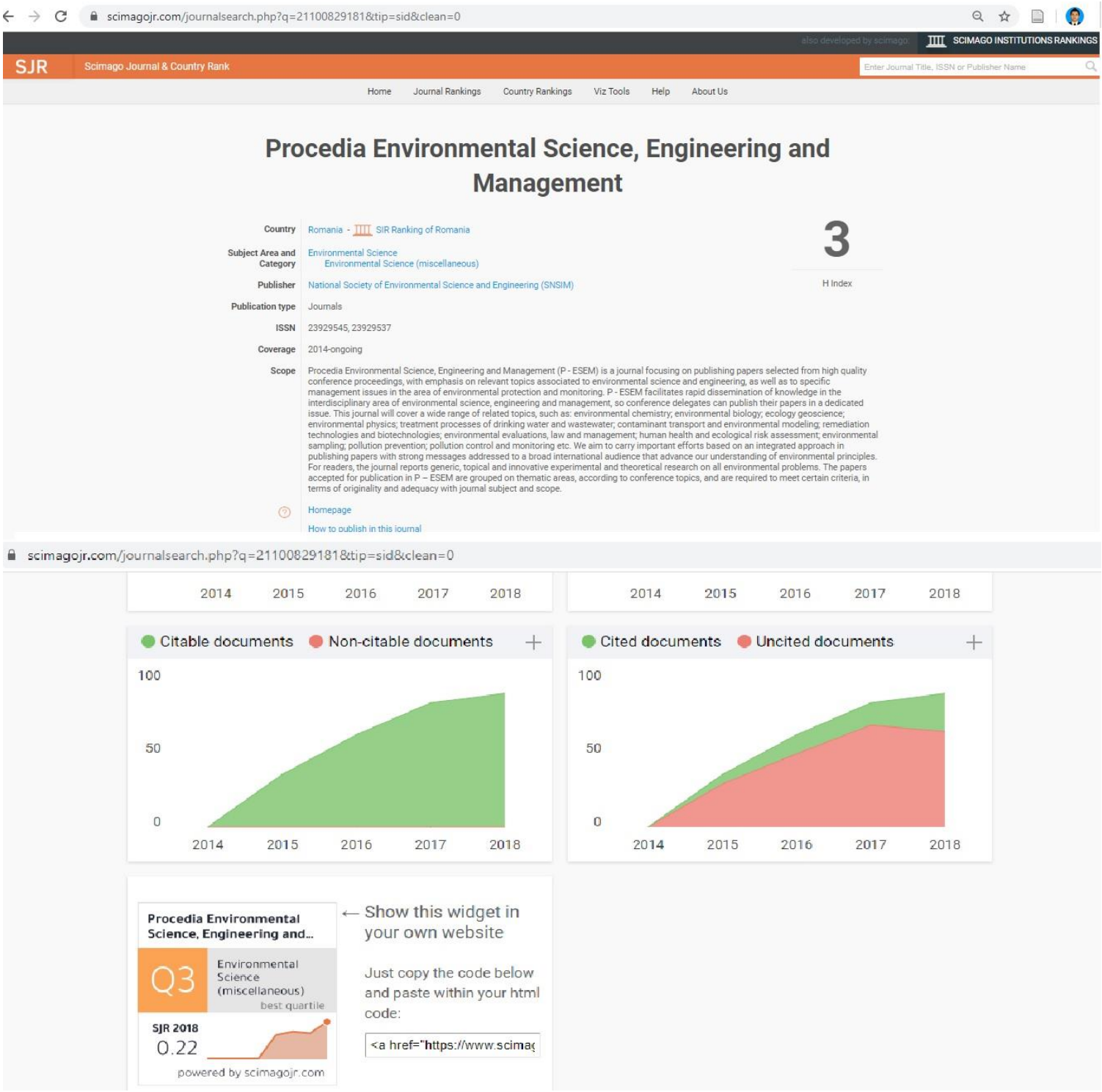
$1.1 = \frac{274 \text{ Citations to date}}{259 \text{ Documents to date}}$

Last updated on 05 November, 2022 • Updated monthly

CiteScore rank 2021

Category	Rank	Percentile
Environmental Science └ General Environmental Science	#173/228	24th

View CiteScore methodology > CiteScore FAQ > Add CiteScore to your site


scimagojr.com/journalsearch.php?q=21100829181&tip=sid&clean=0
SJR
Scimago Journal & Country Rank
SCIMAGO INSTITUTIONS RANKINGS
Home
Journal Rankings
Country Rankings
Viz Tools
Help
About Us
Procedia Environmental Science, Engineering and Management
Country
Romania - SIR Ranking of Romania
Subject Area and Category
Environmental Science
Environmental Science (miscellaneous)
Publisher
National Society of Environmental Science and Engineering (SNSIM)
Publication type
Journals
ISSN
23929545, 23929537
Coverage
2014-ongoing
Scope
Procedia Environmental Science, Engineering and Management (P - ESEM) is a journal focusing on publishing papers selected from high quality conference proceedings, with emphasis on relevant topics associated to environmental science and engineering, as well as to specific management issues in the area of environmental protection and monitoring. P - ESEM facilitates rapid dissemination of knowledge in the interdisciplinary area of environmental science, engineering and management, so conference delegates can publish their papers in a dedicated issue. This journal will cover a wide range of related topics, such as: environmental chemistry; environmental biology; ecology geoscience; environmental physics; treatment processes of drinking water and wastewater; contaminant transport and environmental modeling; remediation technologies and biotechnologies; environmental evaluations, law and management; human health and ecological risk assessment; environmental sampling; pollution prevention; pollution control and monitoring etc. We aim to carry important efforts based on an integrated approach in publishing papers with strong messages addressed to a broad international audience that advance our understanding of environmental principles. For readers, the journal reports generic, topical and innovative experimental and theoretical research on all environmental problems. The papers accepted for publication in P – ESEM are grouped on thematic areas, according to conference topics, and are required to meet certain criteria, in terms of originality and adequacy with journal subject and scope.
Homepage
How to publish in this journal
3
H Index
scimagojr.com/journalsearch.php?q=21100829181&tip=sid&clean=0
2014 2015 2016 2017 2018
Citable documents
Non-citable documents
100
50
0
2014 2015 2016 2017 2018
2014 2015 2016 2017 2018
Cited documents
Uncited documents
100
50
0
2014 2015 2016 2017 2018
Procedia Environmental Science, Engineering and...
Q3
Environmental Science (miscellaneous)
best quartile
SJR 2018
0.22
powered by scimagojr.com
← Show this widget in your own website
Just copy the code below and paste within your html code:
<a href="https://www.scima

Gmail Mareli Telaumbanua <marelitelaumbanua@gmail.com>

Revision of Paper

1 pesan

Mareli Telaumbanua <marelitelaumbanua@gmail.com> 27 Oktober 2020 00.54
Kepada: Andrey Kuzmin <andrey.kuzmin@triacon.org>

Thank you mr Kuzmin

DESIGN OF INSECT TRAP AUTOMATIC CONTROL SYSTEM FOR COCOA PLANTS_Fix.doc
1184K

Procedia
Environmental Science, Engineering and Management
http://www.procedia-esem.eu

DESIGN OF INSECT TRAP AUTOMATIC CONTROL SYSTEM FOR CACAO PLANTS*

Mareli Telaumbanua[1], Agus Haryanto[1], Febryan Kusuma Wisnu[1], Budianto Lanya[1], Wahyu Wiratama[1]**

[1]Department of Agricultural Engineering, Faculty of Agriculture, University of Lampung

Abstract

Insect pests attacks on Cacao (*Theobroma cacao* L) plantations are generally controlled using chemical (non-organic) pesticides. Pesticides that are applied continuously can cause pest resistance, pest resurgence, and environmental pollution. Environmental pollution can disrupt the ecosystem due to increased toxic residues in plant tissue or the soil. Therefore, it is necessary to design a pest trap with charm and an automatic actuator based on a microcontroller on the Arduino board. This automatic insect trap is called the Teptrap v1. Five units of the infrared sensor type E18-D50NK are used to detect insect pests. The attractants used were TL lamps, yellow lights and attractants attached to the trap system. Teptrap v1 shows excellent performance during 33 days of research. As evidenced by the fan actuator system that works stably with a catching accuracy of 82.74%, insect drop time is 6 minutes 33 seconds, and the actuator response speed turns on the light, yellow LED and pumps <1 second (± 10 mS). This insect pest control trap can reduce the use of spray pesticides by 20-50%, thereby saving the cost of purchasing pesticides up to IDR 74,468 per hectare of Cacao.

Keywords: Automatic insect trap, cacao plants, insect trap, microcontroller, pest control

1. Introduction

Cacao is one of the agricultural commodities that have the potential to provide great benefits in Indonesia. However, the pest infestation is the major challenge that faced by the Cacao farmers because it can reduced the production by more than 80% (Basri, 2010). According to Habibullah (2018), Cacao production decreased to 658.400 tons in 2016 which caused by the land reduction of Cacao plantation area due to the farmer's inability to reduce the insect pests attack. Insect pest attacks on Cacao significantly affect the decline in Cacao production (Billah *et al.*, 2014). Insect control on Cacao plants generally uses insecticides. The intensity and dose of insecticides that are applied continuously cause pest resistance to insecticides, pest resurgence, and environmental pollution. One of the causes of damage to Cacao is the attack of insect that suck Cacao pods. The affected fruit shows puncture marks

* Selection and peer-review under responsibility of the EIAETM
** Corresponding author: mareli.telaumbanua@fp.unila.ac.id and marelitelaumbanua@gmail.com

in the form of black spots on the surface of the fruit. In severe attacks, the entire surface of the fruit is covered with black and dry puncture marks; the skin is harden and cracked. This fruit-sucking insect attack is classified as difficult to eradicate because it tends to be resistant to insecticides (Arif, 2015).

Some simple technologies to attract insect include the use of lamps, yellow binders, and attractants. The community tends to use lights to catch flying pests in agricultural areas (Pertiwi *et al.*, 2013). Flying pests are attracted to gathering at light sources. The use of yellow light (waterproof paper material or yellow LED) is also considered as a solution to attracting insects into the trap. The insects have a high interest to yellow color, which provides a stimulus related to changes in plant color during flowering and fruit ripening (Hakim *et al.*, 2017). Another method to trap the insects use as attractants. The odor caused by fruit or synthetic attractants made of methyl eugenol causes fruit flies, Ceratitis sp. and Bactrocera sp. attracted closer to the material. The aroma of the attractant from the hanging methyl eugenol diffuses in the air so that it can be detected by fruit flies (Hasyim *et al.*, 2010). The results of previous research can be used as a reference for a better pest trap design strategy.

A unique strategy need to be developed to deal with Cacao plant pests on an ongoing basis through the application of technology with low operating costs to increase the profit ratio of farmers through designing pest traps with microcontroller based automatic attractants and actuators. The decoys used are TL-lamps, yellow lights, and attractants attached to the trap system. This design tool is called Teptrap v1. The use of this tool works to effectively reduce the effect of pest attacks in preventing insect attacks on cacao plantations.

2. Materials and methods

This research was conducted at the Laboratory of Energy and Agricultural Engineering, Universitas Lampung, Indonesia. The application of insect traps and data collection was carried out in farmers' Cacao farms in Sukoharjo 1 Village, Pringsewu Regency, Lampung.

2.1. Design Criteria

The insect trap automation system is designed to control fan actuators, automatic feeds, infrared sensors, and pumps that are in the insect trap, to lure insects to approach the tool and drop them into an insect reservoir filled with water. The pest trap automation system uses the ATMega microcontroller on the Arduino board because it is easy to assemble, tough, and stable for the use of measurement data acquisition and control system design in agriculture (Waluyo *et al.*, 2020; Telaumbanua *et al.*, 2019; Triyono *et al.*, 2019). The Microcontroller module design is equipped with an LCD, RTC, and MicroSD Module. The power used to turn on the microcontroller and actuator in the pest trap comes from Solar Cell. The electricity generated by the Solar Cell is in the form of DC voltage so that for actuators that require AC voltage electricity is taken from the Solar Cell which has been through the inverter.

The E18-D50NK infrared sensor has a reading accuracy of 1 mm with a detection distance of 50 cm. This infrared sensor can detect changes in infrared energy. This sensor is used to detect insects lured into the pest trap and insects that enter the pest trap. The design of the types of decoys used in the traps is TL-lamps, yellow multi LEDs, and attractants. The design of actuators used in pest traps is to use a fan, a decoy (TL-lamp, yellow light, attractant) and a water pump with a voltage of 220V and a power of 35 watts. The fan blows the wind to knock down insects when insects detected by infrared sensors are inside the pest trap catching room. The use of a water pump functions to circulate water in the insect collection tub at 06.15-06.30 AM to prevent trapped insects from escape and to make it easier for researchers to count insects (for analysis) manually. The seductive TL-lamp are

turned on at 6.00 PM - 06.00 AM, while the yellow and attractant lights are always on (Figure 1).

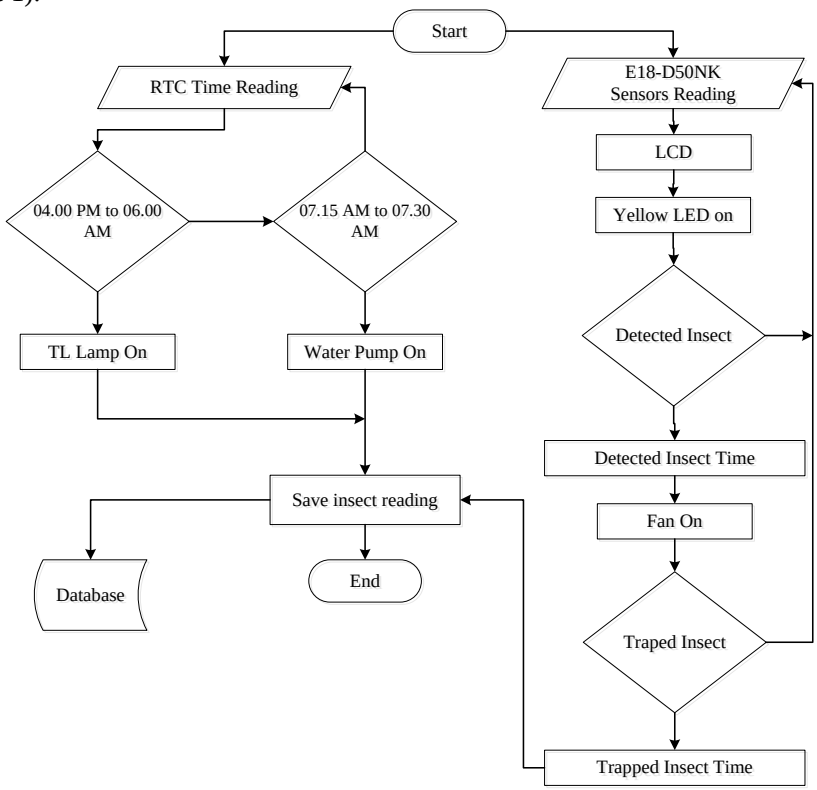


Figure 1. Flow diagram of insect trap Teptrap v1

The pest trapping framework was designed regarding research on the design of a rice plant pest-trap device using Arduino mega2560 (Cahyono, 2015). Pest traps are installed at the height of 1 meter above the ground. The height of the solar panels from the ground is 4 meters so that the solar panels get maximum sunlight, not shaded by trees—pest trap design, as shown in Figure 2.

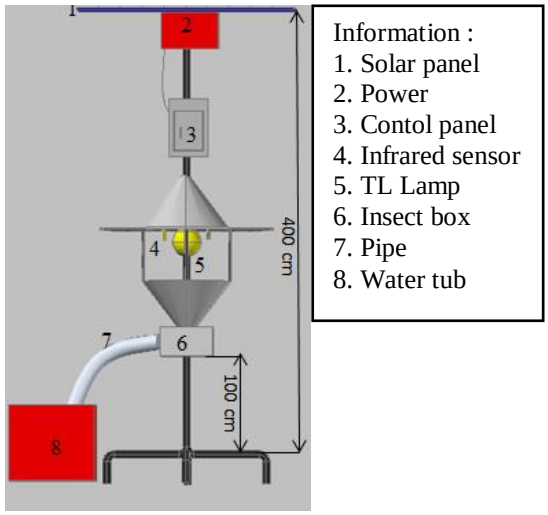


Figure 2. Prototype of cacao insect trap

2.2. Field Test

The research begins with designing and assembling insect traps using hardware and software. Before using the infrared sensor, calibrate the reading distance by adjusting the reading distance by turning the infrared sensor potentiometer. The next step is to know the speed of reading on each infrared sensor used. The aim is to adjust the turn on the fan actuator to drop insects. Then, the insect comes and is detected by the sensor. The sensor sends a signal to Arduino then Arduino processes and sends a command to turn on the fan actuator (on) so that the insects are pushed into the insect collection tub. No insects approaching the tool makes the infrared sensor not send a signal to Arduino, so Arduino does not turn on the fan (off).

The observation variable carried out in this research is the number of insects caught in automatic Cacao pest traps compared to the number of insects trapped by yellow traps and attractant traps commonly used by farmers. Observation aims to determine the effect of using an automatic control system on pest traps. Observational data were measured once a day for 44 days. Data when insects arrive and insects that fall into the insect container will be stored in the MicroSD card Module.

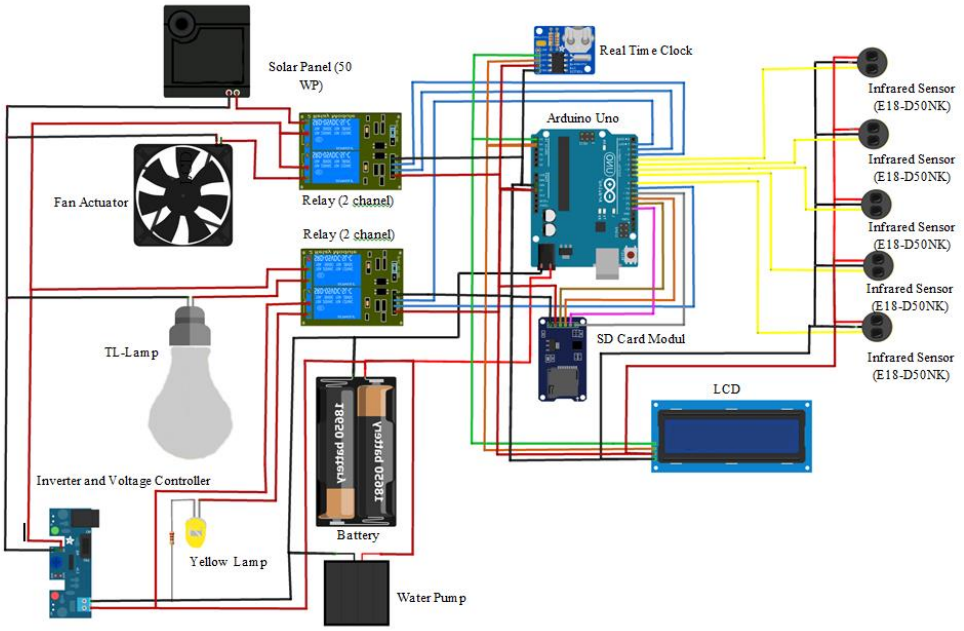


Figure 3. Schematic of sensor and actuator

The Teptrap v1 sensor design uses five detection sensors. Four units of sensors are used to detect insects and the fan actuator activator (Figure 3). One sensor unit is placed in the insect shelter funnel, which can count incoming insects. The performance of actuators and types of decoys in the insect trap control system (Teptrap v1) measured includes the accuracy of sensor readings of various insect sizes, response speed, stability, system accuracy, and the average time of insect dropping.

3. Results and discussion

3.1. Design of Automatic Insect Trap for Cacao Plants

The automatic pest trap called Teptrap v1 has been successfully designed and tested to attract and catch Cacao insect pests. This trap is expected to be able to reduce population numbers and insect attacks on Cacao plantations. Also, the use of automatic insect traps is expected to reduce the use of chemical pesticides in pest management to reduce

environmental pollution. The insect traps are designed in the form of a cylindrical frame with a height of 4 meters, a height of 40 cm in fishing space, and a diameter of 40 cm. The top and bottom of the trap space are cone-shaped with a height of 40 cm and a diameter of 60 cm, equipped with a temporary insect storage box measuring 40 cm x 30 cm x 20 cm (Figure 4). The part of the support pole in the middle of the tool is slightly tilted to increase the strength of the support pole. This trap room features an insect drive fan actuator, TL lamp, attractant, yellow LED and an E18-D50NK sensor. In this automatic insect trap, the ATmega328 microcontroller on Arduino Uno functions as a data processor. It is integrated with various actuators for supporting components such as LCD, RTC, MMC. 2 channel Relay Module, and so on.

The energy of this insect trap comes from solar panels that convert sunlight into electricity. The power supply component consists of 2 solar cells with a capacity of 50 WP, a 45Ah battery, solar control charge, and a 300-watt inverter. The solar cell used has a capacity of 100 WP which means that the solar cell can produce 100 watts of power when the sun is hot (not obstructed by clouds).

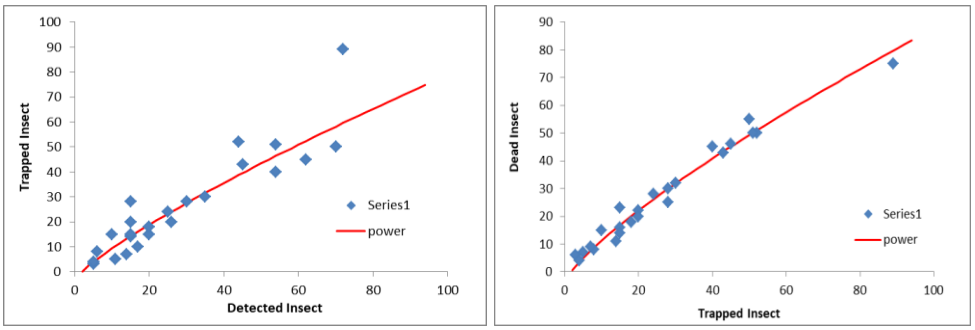
Figure 4. The automatic insect trap in cacao plantation

3.2. Mathematical Model of Trap Sensor and Detection Sensor

The relationship between detected insect sensor readings (x) and trapped insect sensor readings (y) is $y = 1.879 * x^{0.82} - 3.1$. The data from the detected insects and trapped insects showed a strong relationship with a correlation coefficient value of 0.812 (Figure 5a). The results of the observation data on insects coming and insects entering resulted in an RRMSE value of 31.9% (Haryanto *et al.,* 2020). The RRMSE value between the detection sensor and the trapped sensor has a high average error value because not all insects that come and are detected are trapped into the instrument. The reading of the number of insects on the trapped sensor is more than the detection sensor because the insects come in groups, so the detection sensor reads one in each group.

The correlation between trapped insects (x) and dead insects (y) is $y = 2.438 * x^{0.786} - 3.65$. The data on this graph shows that there is only a slight difference between the sensor readings for trapped insects and those that are dead (calculated manually). Data from observations of trapped insects with dead insects show a strong correlation coefficient with a value of 0.974 (Figure 5b). The results from the data on incoming insects and dead insects resulted in an RRMSE value of 15.1%. This RRMSE

value shows that the number of insects read by the trapped insect sensor and the number of dead insects has a small average error value. The cause of the number of insects killed is more than the insects read by the incoming sensor is because the size of the insects is below 1 mm, so the sensor cannot detect these insects.



(a) (b)

Figure 5. (a) Correlation of incoming insect vs incoming insect sensor readings; (b) Correlation of sensor readings for incoming insects vs dead insects (manual count)

3.3. Control system performance

3.3.1. Efficiency

The efficiency of catching insects is carried out by observing the number of insects counted by the detection sensor and the insect counter sensor trapped in the insect storage tank (Figure 6). Detected insects are defined as insect pests detected by four detection sensor units. Trapped insects are insects that are counted by one trapped counter sensor unit, and dead insects are defined as the number of insects that are counted manually to determine the catch performance by the design of the pest trapping tool. Manual calculations are carried out on the filter in place after water storage (trap box). Pests that enter the filter have died from being submerged in water so that they can be counted manually.

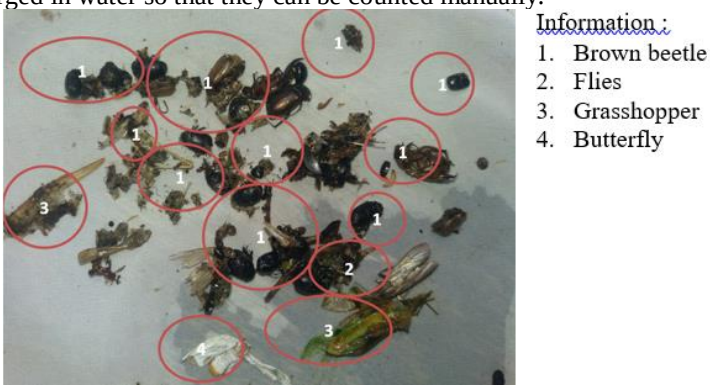


Figure 6. Trapped Insects

The catch efficiency is defined as the accuracy of the fan actuator in pushing insect pests into the trap (water reservoir) based on the detected insects. This value can also be called the system accuracy in catching insects with the following formula:

$$Ep = \frac{\sum_{i=1}^{n}(\frac{So}{Si} x100)}{n}$$

Where :

Ep = catch efficiency (%)

So = dead insects
Si = detected insects
n = number of observation days
From the calculation results, the total efficiency in catching insects for 33 days is 82.74%.

3.3.2. Insects drop control speed

The insect drop control speed is defined as the average time it takes the actuator to drop the insect when an insect passes the sensor.
The formula for calculating the controlling speed of a fan actuator is:

$$RWP = \frac{\sum_{i=1}^{n}(Aon\ i + Delay)}{n}$$

Where :
RWP = average time of falling insects
Aon i = actuator turn on to-i (minutes)
Delay = time until the detection sensor doesn't read the insects (minutes)
n = data amount
From the observations, the speed of falling insects for 24 hours of observation is 6 minutes 33 seconds and the automatic insect trapping system works stably.

3.3.3. The response speed to turns on the actuator

The response speed to the tool design setting point in turning on the TL lamp actuator, the yellow multi-LED actuator and the water pump actuator takes <1 second (± 10 mS). This is because the speed of the microcontroller to execute commands takes 10 mS for each order (Telaumbanua *et al.*, 2020).

3.3.4. Stability

Capture stability is defined as the ability of the tool (trap) to work precisely in detecting and making arrests over a long period. Good system stability is a system that can detect, measure, execute instructions, and activate actuators equally well, without experiencing significant deterioration in performance.

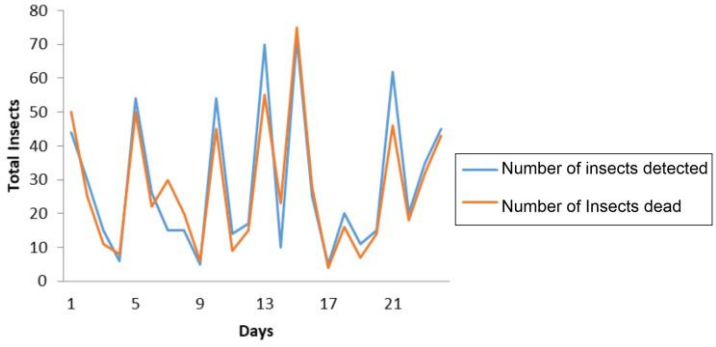


Figure 7. Stability of Insect trap

The performance of the Teptrap v1 tool in catching insects, as shown in Figure 7, can be said to be stable because the insect sensor values detected by the dead insects did not differ significantly. The fluctuation of insect fishing is caused by environmental factors such as wind speed, air temperature and rainfall intensity.

Some research report that the use of insect traps can reduce the use of chemical pesticides by 20-50%. The Teptrap v1 has the advantage compared to the common insect trap which only have one manual trap, so it is expected that Teptrap v1 can be more effective to reduce the use of pesticide. This is certainly able to save the maintenance costs of

plantation crops of IDR 74,468 per hectare of cacao crop in the cost of purchasing pesticides (Bunga, 2016).

5. Conclusion

Based on the research results, the design of the cacao insect trap actuator for 33 days has shown excellent performance. This is evidenced by the fan actuator system that works with an efficiency value (accuracy of capture) of 82.74%, the time it takes for the fan to drop the insects is 6 minutes 33 seconds. The actuator response speed turns on the lamp, the yellow LED and the pump takes <1 second and the system works stably. Automatic pest traps Traptep v1 was able to catch insects very well, as evidenced by the correlation coefficient of detected insect readings and trapped insects were 0.812, while the correlation between trapped insects and dead insects was 0.974. The use of this trap can reduce the impact of insect attacks because it slows down the rate of reproduction of insect pests. This is undoubtedly able to minimize the use of non-organic pesticides in pest control.

6. References

Arif, A. (2015). Pengaruh Bahan Kimia Terhadap Penggunaan Pestisida Lingkungan, *Jf FIK Uinam*, 3(4) : 134-143

Basri, A.B. (2010). Pengendalian Hama Utama Buah Kakao. Balai Pengkajian Teknologi Pertanian (BPTP) Aceh. *Serambi Pertanian*. 4(2): 1–2.

Billah, T., Cakrabawa, D., Nuryati, L., Susanti, A.A. (2014). *Outlook Komoditi Kakao*. Pusat Data dan Sistem Informasi Pertanian Sekretariat Jenderal Kementerian Pertanian 2014, Jakarta.

Bunga, N, I. (2016). The Analysis of Cacao Farming Income at Soe Village Pamona Puselemba Distric. *Jurnal envira*. 2 (1): 28-33.

Cahyono, G.R., Nurmahaludin. (2015). Rancang Bangun Alat Perangkap Hama Tanaman Padi Menggunakan Arduino MEGA 2560. *Jurnal Poros Teknik*, 7 (2): 54-60.

Habibullah, M. (2018). *Statistik Kakao Indonesia 2017*. Badan Pusat Statistik, Indonesia, Jakarta.

Hakim, L., Surya, E., Muis, A. (2017). Pengendalian Alternatif Hama Serangga Sayuran dengan Menggunakan Warna sebagai Perangkap Mekanis, *Serambi Saintia : Jurnal Sains dan Aplikasi*.5 (1): 33 - 44.

Haryanto, A., Saputra, T. W., Telaumbanua, M., Gita. A. C. (2020). Application of Artificial Neural Network to Predict Biodiesel Yield from Waste Frying Oil Transesterification. *Indonesian Journal of Science & Technology*. 5 (1) : 62-74.

Hasyim, A., Boy, A., Hilman, Y. (2010). Respons Hama Lalat Buah Jantan terhadap beberapa Jenis Atraktan dan Warna Perangkap di Kebun Petani. *J.Hort*. 20(2):164-170.

Pertiwi, E.N., Mudjiono, G., Rachmawati, R. (2013). Hubungan Populasi Ngengat Penggerek Batang Padi yang Tertangkap Perangkat Lampu Dengan Intensitas Serangan Penggerek Batang Padi di Sekitarnya. *Jurnal HPT*. 1 (2): 88-92.

Telaumbanua, M., Baene, E. K., Ridwan., Haryanto, A., Wisnu, F. K., Suharyatun, S. (2020). Irrigation Water Gate Monitoring System Based on The Internet of Things Using Microcontroller. *IOP Conference Series: Earth and Environmental Science* (accepted).

Telaumbanua, M., Triyono, S., Haryanto, A., Wisnu, F, K. (2019). Controlled Electrical Conductivity (Ec) Of Tofu Wastewater As A Hydroponic Nutrition. *Procedia Environmental Science, Engineering and Management* 6 (3): 452-463.

Triyono, S., Haryanto, A., Telaumbanua, M., Dermiyati., Lumbanraja, J., Filip, T. (2019), Cultivation of straw mushroom (Volvariella volvacea) on oil palm empty fruit bunch growth medium, *International Journal of Recycling of Organic Waste in Agriculture*, 8 : 381–392.

Waluyo, S., Ardiyanto, A., Telaumbanua M. (2020), Determination of thermal Difusifity of Corn Kernel Using Numerical Method. *IOP Conference Series: Earth and Environmental Science* (accepted).

Gmail Mareli Telaumbanua <marelitelaumbanua@gmail.com>

Revision of Paper : Desain of Automatic Trap

1 pesan

Mareli Telaumbanua <marelitelaumbanua@gmail.com> 28 Oktober 2020 00.53
Kepada: Andrey Kuzmin <andrey.kuzmin@triacon.org>

thank you mr. Kuzmin

2 lampiran

DESIGN OF INSECT TRAP AUTOMATIC CONTROL SYSTEM FOR COCOA PLANTS_Fix_(bibliography without accepted paper).doc
1116K

DESIGN OF INSECT TRAP AUTOMATIC CONTROL SYSTEM FOR COCOA PLANTS_Fix_(bibliography using accepted paper).doc
1117K

REVISI Akhir, 29 Oktober 2020

SNSIM

Procedia
Environmental Science, Engineering and Management
http://www.procedia-esem.eu

DESIGN OF INSECT TRAP AUTOMATIC CONTROL SYSTEM FOR CACAO PLANTS*

Mareli Telaumbanua[1], Agus Haryanto[1], Febryan Kusuma Wisnu[1], Budianto Lanya[1], Wahyu Wiratama[1]**

[1]*Department of Agricultural Engineering, Faculty of Agriculture, University of Lampung*

Abstract

Insect pests attacks on Cacao (*Theobroma cacao* L) plantations are generally controlled using chemical (non-organic) pesticides. Pesticides that are applied continuously can cause pest resistance, pest resurgence, and environmental pollution. Environmental pollution can disrupt the ecosystem due to increased toxic residues in plant tissue or the soil. Therefore, it is necessary to design a pest trap with charm and an automatic actuator based on a microcontroller on the Arduino board. This automatic insect trap is called the Teptrap v1. Five units of the infrared sensor type E18-D50NK are used to detect insect pests. The attractants used were TL lamps, yellow lights and attractants attached to the trap system. Teptrap v1 shows excellent performance during 33 days of research. As evidenced by the fan actuator system that works stably with a catching accuracy of 82.74%, insect drop time is 6 minutes 33 seconds, and the actuator response speed turns on the light, yellow LED and pumps <1 second (± 10 mS). This insect pest control trap can reduce the use of spray pesticides by 20-50%, thereby saving the cost of purchasing pesticides up to IDR 74,468 per hectare of Cacao.

Keywords: Automatic insect trap, cacao plants, insect trap, microcontroller, pest control

1. Introduction

Cacao is one of the agricultural commodities that have the potential to provide great benefits in Indonesia. However, the pest infestation is the major challenge that faced by the Cacao farmers because it can reduced the production by more than 80% (Basri, 2010). According to Habibullah (2018), Cacao production decreased to 658.400 tons in 2016 which caused by the land reduction of Cacao plantation area due to the farmer's inability to reduce the insect pests attack. Insect pest attacks on Cacao significantly affect the decline in Cacao production (Billah *et al.*, 2014). Insect control on Cacao plants generally uses insecticides. The intensity and dose of insecticides that are applied continuously cause pest resistance to insecticides, pest resurgence, and environmental pollution. One of the causes of damage to Cacao is the attack of insect that suck Cacao pods. The affected fruit shows puncture marks

* Selection and peer-review under responsibility of the EIAETM
** Corresponding author: mareli.telaumbanua@fp.unila.ac.id and marelitelaumbanua@gmail.com

in the form of black spots on the surface of the fruit. In severe attacks, the entire surface of the fruit is covered with black and dry puncture marks; the skin is harden and cracked. This fruit-sucking insect attack is classified as difficult to eradicate because it tends to be resistant to insecticides (Arif, 2015).

Some simple technologies to attract insect include the use of lamps, yellow binders, and attractants. The community tends to use lights to catch flying pests in agricultural areas (Pertiwi *et al.*, 2013). Flying pests are attracted to gathering at light sources. The use of yellow light (waterproof paper material or yellow LED) is also considered as a solution to attracting insects into the trap. The insects have a high interest to yellow color, which provides a stimulus related to changes in plant color during flowering and fruit ripening (Hakim *et al.*, 2017). Another method to trap the insects use as attractants. The odor caused by fruit or synthetic attractants made of methyl eugenol causes fruit flies, Ceratitis sp. and Bactrocera sp. attracted closer to the material. The aroma of the attractant from the hanging methyl eugenol diffuses in the air so that it can be detected by fruit flies (Hasyim *et al.*, 2010). The results of previous research can be used as a reference for a better pest trap design strategy.

A unique strategy need to be developed to deal with Cacao plant pests on an ongoing basis through the application of technology with low operating costs to increase the profit ratio of farmers through designing pest traps with microcontroller based automatic attractants and actuators. The decoys used are TL-lamps, yellow lights, and attractants attached to the trap system. This design tool is called Teptrap v1. The use of this tool works to effectively reduce the effect of pest attacks in preventing insect attacks on cacao plantations.

2. Materials and methods

This research was conducted at the Laboratory of Energy and Agricultural Engineering, Universitas Lampung, Indonesia. The application of insect traps and data collection was carried out in farmers' Cacao farms in Sukoharjo 1 Village, Pringsewu Regency, Lampung.

2.1. Design Criteria

The insect trap automation system is designed to control fan actuators, automatic feeds, infrared sensors, and pumps that are in the insect trap, to lure insects to approach the tool and drop them into an insect reservoir filled with water. The pest trap automation system uses the ATMega microcontroller on the Arduino board because it is easy to assemble, tough, and stable for the use of measurement data acquisition and control system design in agriculture (Telaumbanua *et al.*, 2019; Triyono *et al.*, 2019). The Microcontroller module design is equipped with an LCD, RTC, and MicroSD Module. The power used to turn on the microcontroller and actuator in the pest trap comes from Solar Cell. The electricity generated by the Solar Cell is in the form of DC voltage so that for actuators that require AC voltage electricity is taken from the Solar Cell which has been through the inverter.

The E18-D50NK infrared sensor has a reading accuracy of 1 mm with a detection distance of 50 cm. This infrared sensor can detect changes in infrared energy. This sensor is used to detect insects lured into the pest trap and insects that enter the pest trap. The design of the types of decoys used in the traps is TL-lamps, yellow multi LEDs, and attractants. The design of actuators used in pest traps is to use a fan, a decoy (TL-lamp, yellow light, attractant) and a water pump with a voltage of 220V and a power of 35 watts. The fan blows the wind to knock down insects when insects detected by infrared sensors are inside the pest trap catching room. The use of a water pump functions to circulate water in the insect collection tub at 06.15-06.30 AM to prevent trapped insects from escape and to make it easier for researchers to count insects (for analysis) manually. The seductive TL-lamp are turned on at 6.00 PM - 06.00 AM, while the yellow and attractant lights are always on (Figure 1).

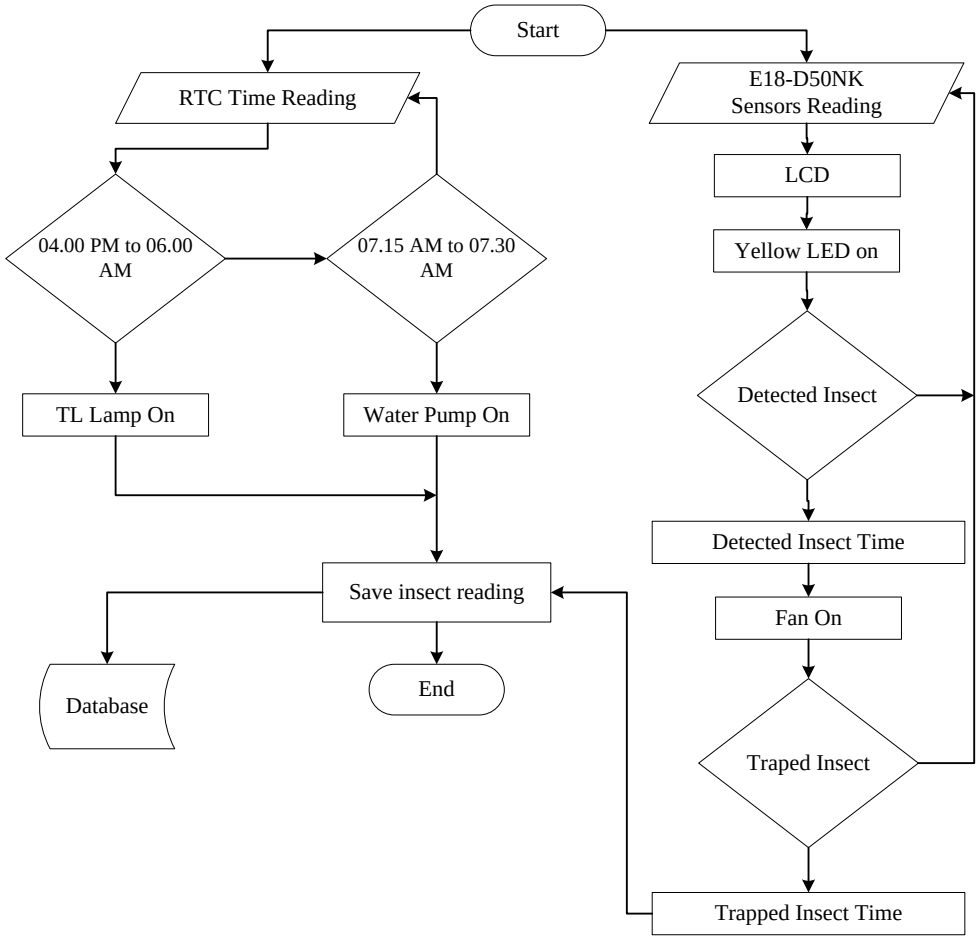


Figure 1. Flow diagram of insect trap Teptrap v1

The pest trapping framework was designed regarding research on the design of a rice plant pest-trap device using Arduino mega2560 (Cahyono, 2015). Pest traps are installed at the height of 1 meter above the ground. The height of the solar panels from the ground is 4 meters so that the solar panels get maximum sunlight, not shaded by trees—pest trap design, as shown in Figure 2.

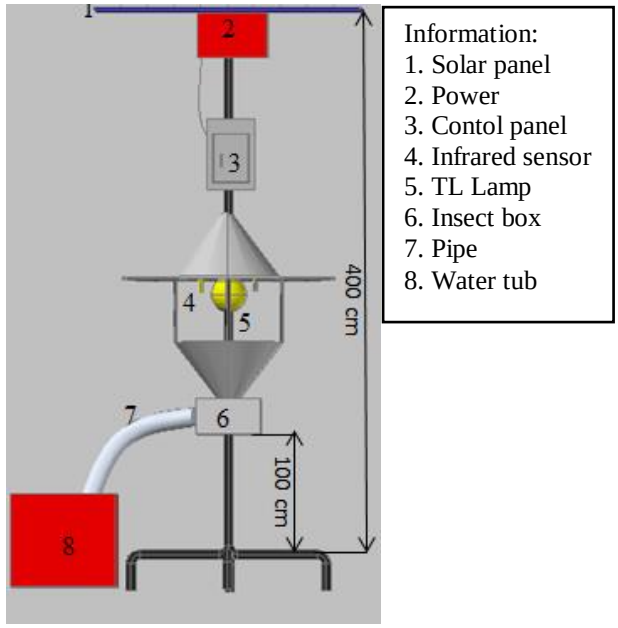


Figure 2. Prototype of cacao insect trap

2.2. Field Test

The research begins with designing and assembling insect traps using hardware and software. Before using the infrared sensor, calibrate the reading distance by adjusting the reading distance by turning the infrared sensor potentiometer. The next step is to know the speed of reading on each infrared sensor used. The aim is to adjust the turn on the fan actuator to drop insects. Then, the insect comes and is detected by the sensor. The sensor sends a signal to Arduino then Arduino processes and sends a command to turn on the fan actuator (on) so that the insects are pushed into the insect collection tub. No insects approaching the tool makes the infrared sensor not send a signal to Arduino, so Arduino does not turn on the fan (off).

The observation variable carried out in this research is the number of insects caught in automatic Cacao pest traps compared to the number of insects trapped by yellow traps and attractant traps commonly used by farmers. Observation aims to determine the effect of using an automatic control system on pest traps. Observational data were measured once a day for 44 days. Data when insects arrive and insects that fall into the insect container will be stored in the MicroSD card Module.

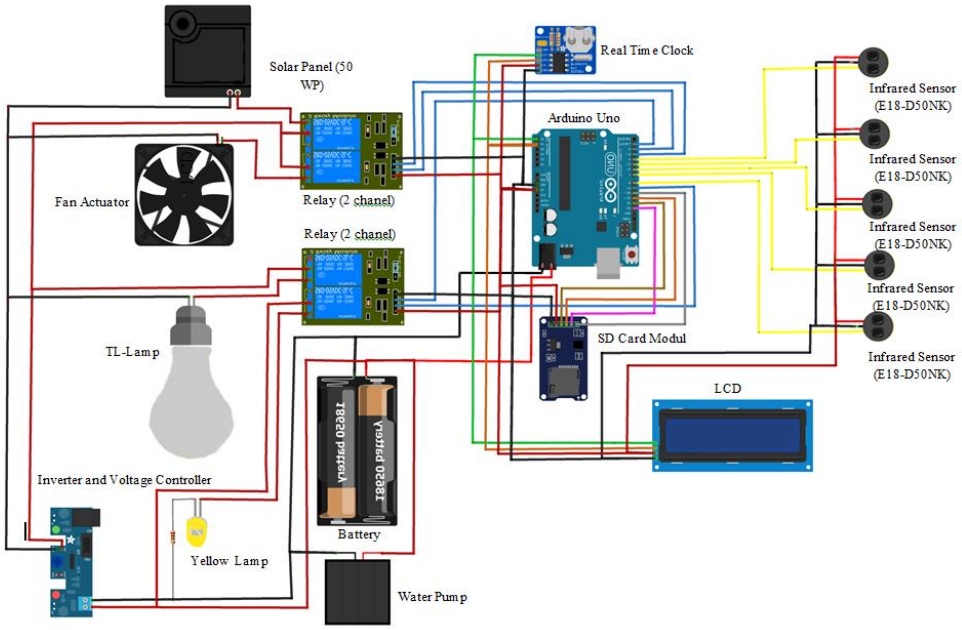


Figure 3. Schematic of sensor and actuator

The Teptrap v1 sensor design uses five detection sensors. Four units of sensors are used to detect insects and the fan actuator activator (Figure 3). One sensor unit is placed in the insect shelter funnel, which can count incoming insects. The performance of actuators and types of decoys in the insect trap control system (Teptrap v1) measured includes the accuracy of sensor readings of various insect sizes, response speed, stability, system accuracy, and the average time of insect dropping.

3. Results and discussion

3.1. Design of Automatic Insect Trap for Cacao Plants

The automatic pest trap called Teptrap v1 has been successfully designed and tested to attract and catch Cacao insect pests. This trap is expected to be able to reduce population numbers and insect attacks on Cacao plantations. Also, the use of automatic insect traps is expected to reduce the use of chemical pesticides in pest management to reduce environmental pollution. The insect traps are designed in the form of a cylindrical frame with a height of 4 meters, a height of 40 cm in fishing space, and a diameter of 40 cm. The top and bottom of the trap space are cone-shaped with a height of 40 cm and a diameter of 60 cm, equipped with a temporary insect storage box measuring 40 cm x 30 cm x 20 cm (Figure 4). The part of the support pole in the middle of the tool is slightly tilted to increase the strength of the support pole. This trap room features an insect drive fan actuator, TL lamp, attractant, yellow LED and an E18-D50NK sensor. In this automatic insect trap, the ATmega328 microcontroller on Arduino Uno functions as a data processor. It is integrated with various actuators for supporting components such as LCD, RTC, MMC. 2 channel Relay Module, and so on.

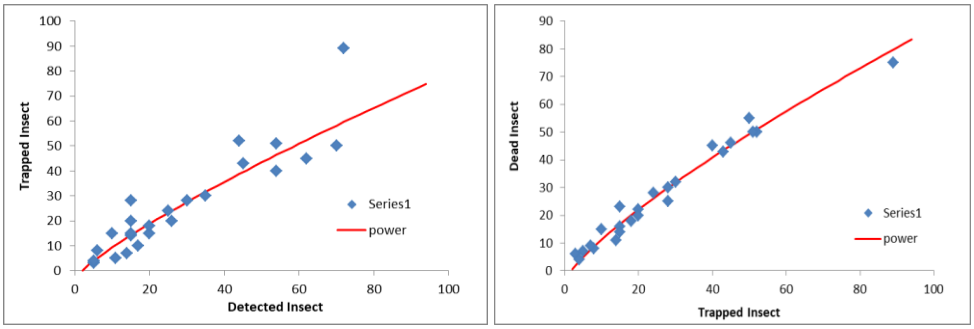
The energy of this insect trap comes from solar panels that convert sunlight into electricity. The power supply component consists of 2 solar cells with a capacity of 50 WP, a 45Ah battery, solar control charge, and a 300-watt inverter. The solar cell used has a capacity of 100 WP which means that the solar cell can produce 100 watts of power when the sun is hot (not obstructed by clouds).

Figure 4. The automatic insect trap in cacao plantation

3.2. Mathematical Model of Trap Sensor and Detection Sensor

The relationship between detected insect sensor readings (x) and trapped insect sensor readings (y) is $y = 1.879 * x^{0.82} - 3.1$. The data from the detected insects and trapped insects showed a strong relationship with a correlation coefficient value of 0.812 (Figure 5a). The results of the observation data on insects coming and insects entering resulted in an RRMSE value of 31.9% (Haryanto *et al.*, 2020). The RRMSE value between the detection sensor and the trapped sensor has a high average error value because not all insects that come and are detected are trapped into the instrument. The reading of the number of insects on the trapped sensor is more than the detection sensor because the insects come in groups, so the detection sensor reads one in each group.

The correlation between trapped insects (x) and dead insects (y) is $y = 2.438 * x^{0.786} - 3.65$. The data on this graph shows that there is only a slight difference between the sensor readings for trapped insects and those that are dead (calculated manually). Data from observations of trapped insects with dead insects show a strong correlation coefficient with a value of 0.974 (Figure 5b). The results from the data on incoming insects and dead insects resulted in an RRMSE value of 15.1%. This RRMSE value shows that the number of insects read by the trapped insect sensor and the number of dead insects has a small average error value. The cause of the number of insects killed is more than the insects read by the incoming sensor is because the size of the insects is below 1 mm, so the sensor cannot detect these insects.



(a) (b)

Figure 5. (a) Correlation of incoming insect vs incoming insect sensor readings; (b) Correlation of sensor readings for incoming insects vs dead insects (manual count)

3.3. Control system performance

3.3.1. Efficiency

The efficiency of catching insects is carried out by observing the number of insects counted by the detection sensor and the insect counter sensor trapped in the insect storage tank (Figure 6). Detected insects are defined as insect pests detected by four detection sensor units. Trapped insects are insects that are counted by one trapped counter sensor unit, and dead insects are defined as the number of insects that are counted manually to determine the catch performance by the design of the pest trapping tool. Manual calculations are carried out on the filter in place after water storage (trap box). Pests that enter the filter have died from being submerged in water so that they can be counted manually.

Figure 6. Trapped Insects

The catch efficiency is defined as the accuracy of the fan actuator in pushing insect pests into the trap (water reservoir) based on the detected insects. This value can also be called the system accuracy in catching insects with the following formula:

$$Ep = \frac{\sum_{i=1}^{n}(\frac{So}{Si} x100)}{n}$$

Where :

Ep = catch efficiency (%)

So = dead insects

Si = detected insects

n = number of observation days

From the calculation results, the total efficiency in catching insects for 33 days is 82.74%.

3.3.2. Insects drop control speed

The insect drop control speed is defined as the average time it takes the actuator to drop the insect when an insect passes the sensor.

The formula for calculating the controlling speed of a fan actuator is:

$$\text{RWP} = \frac{\sum_{i=1}^{n}(Aon\ i + Delay)}{n}$$

Where :

RWP = average time of falling insects

Aon i = actuator turn on to-i (minutes)

Delay = time until the detection sensor doesn't read the insects (minutes)

n = data amount

From the observations, the speed of falling insects for 24 hours of observation is 6 minutes 33 seconds and the automatic insect trapping system works stably.

3.3.3. The response speed to turns on the actuator

The response speed to the tool design setting point in turning on the TL lamp actuator, the yellow multi-LED actuator and the water pump actuator takes <1 second (± 10 mS). This is because the speed of the microcontroller to execute commands takes 10 mS for each order.

3.3.4. Stability

Capture stability is defined as the ability of the tool (trap) to work precisely in detecting and making arrests over a long period. Good system stability is a system that can detect, measure, execute instructions, and activate actuators equally well, without experiencing significant deterioration in performance.

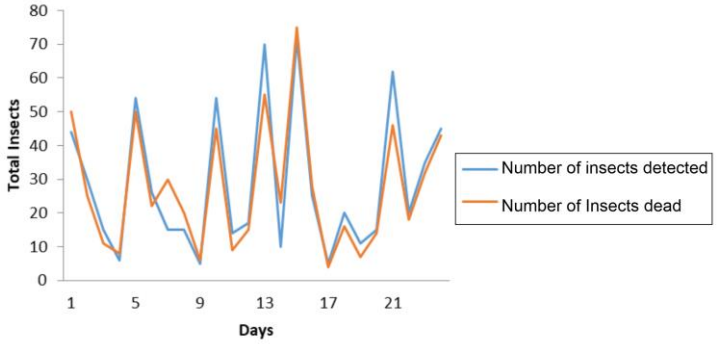


Figure 7. Stability of Insect trap

The performance of the Teptrap v1 tool in catching insects, as shown in Figure 7, can be said to be stable because the insect sensor values detected by the dead insects did not differ significantly. The fluctuation of insect fishing is caused by environmental factors such as wind speed, air temperature and rainfall intensity.

Some research report that the use of insect traps can reduce the use of chemical pesticides by 20-50%. The Teptrap v1 has the advantage compared to the common insect trap which only have one manual trap, so it is expected that Teptrap v1 can be more effective to reduce the use of pesticide. This is certainly able to save the maintenance costs of plantation crops of IDR 74,468 per hectare of cacao crop in the cost of purchasing pesticides (Bunga, 2016).

5. Conclusion

Based on the research results, the design of the cacao insect trap actuator for 33 days has shown excellent performance. This is evidenced by the fan actuator system that works with an efficiency value (accuracy of capture) of 82.74%, the time it takes for the fan to drop the insects is 6 minutes 33 seconds. The actuator response speed turns on the lamp, the yellow LED and the pump takes <1 second and the system works stably. Automatic pest traps Traptep v1 was able to catch insects very well, as evidenced by the correlation coefficient of detected insect readings and trapped insects were 0.812, while the correlation between trapped insects and dead insects was 0.974. The use of this trap can reduce the impact of insect attacks because it slows down the rate of reproduction of insect pests. This is undoubtedly able to minimize the use of non-organic pesticides in pest control.

6. References

Arif, A. (2015). Pengaruh Bahan Kimia Terhadap Penggunaan Pestisida Lingkungan, *Jf FIK Uinam*, 3(4) : 134-143

Basri, A.B. (2010). Pengendalian Hama Utama Buah Kakao. Balai Pengkajian Teknologi Pertanian (BPTP) Aceh. *Serambi Pertanian*. 4(2): 1–2.

Billah, T., Cakrabawa, D., Nuryati, L., Susanti, A.A. (2014). *Outlook Komoditi Kakao*. Pusat Data dan Sistem Informasi Pertanian Sekretariat Jenderal Kementerian Pertanian 2014, Jakarta.

Bunga, N, I. (2016). The Analysis of Cacao Farming Income at Soe Village Pamona Puselemba Distric. *Jurnal envira*. 2 (1): 28-33.

Cahyono, G.R., Nurmahaludin. (2015). Rancang Bangun Alat Perangkap Hama Tanaman Padi Menggunakan Arduino MEGA 2560. *Jurnal Poros Teknik*, 7 (2): 54-60.

Habibullah, M. (2018). *Statistik Kakao Indonesia 2017*. Badan Pusat Statistik, Indonesia, Jakarta.

Hakim, L., Surya, E., Muis, A. (2017). Pengendalian Alternatif Hama Serangga Sayuran dengan Menggunakan Warna sebagai Perangkap Mekanis, *Serambi Saintia : Jurnal Sains dan Aplikasi*.5 (1): 33 - 44.

Haryanto, A., Saputra, T. W., Telaumbanua, M., Gita. A. C. (2020). Application of Artificial Neural Network to Predict Biodiesel Yield from Waste Frying Oil Transesterification. *Indonesian Journal of Science & Technology*. 5 (1) : 62-74.

Hasyim, A., Boy, A., Hilman, Y. (2010). Respons Hama Lalat Buah Jantan terhadap beberapa Jenis Atraktan dan Warna Perangkap di Kebun Petani. *J.Hort*. 20(2):164-170.

Pertiwi, E.N., Mudjiono, G., Rachmawati, R. (2013). Hubungan Populasi Ngengat Penggerek Batang Padi yang Tertangkap Perangkat Lampu Dengan Intensitas Serangan Penggerek Batang Padi di Sekitarnya. *Jurnal HPT*. 1 (2): 88-92.

Telaumbanua, M., Triyono, S., Haryanto, A., Wisnu, F, K. (2019). Controlled Electrical Conductivity (Ec) Of Tofu Wastewater As A Hydroponic Nutrition. *Procedia Environmental Science, Engineering and Management* 6 (3): 452-463.

Triyono, S., Haryanto, A., Telaumbanua, M., Dermiyati., Lumbanraja, J., Filip, T. (2019), Cultivation of straw mushroom (Volvariella volvacea) on oil palm empty fruit bunch growth medium, *International Journal of Recycling of Organic Waste in Agriculture*, 8 : 381–392.

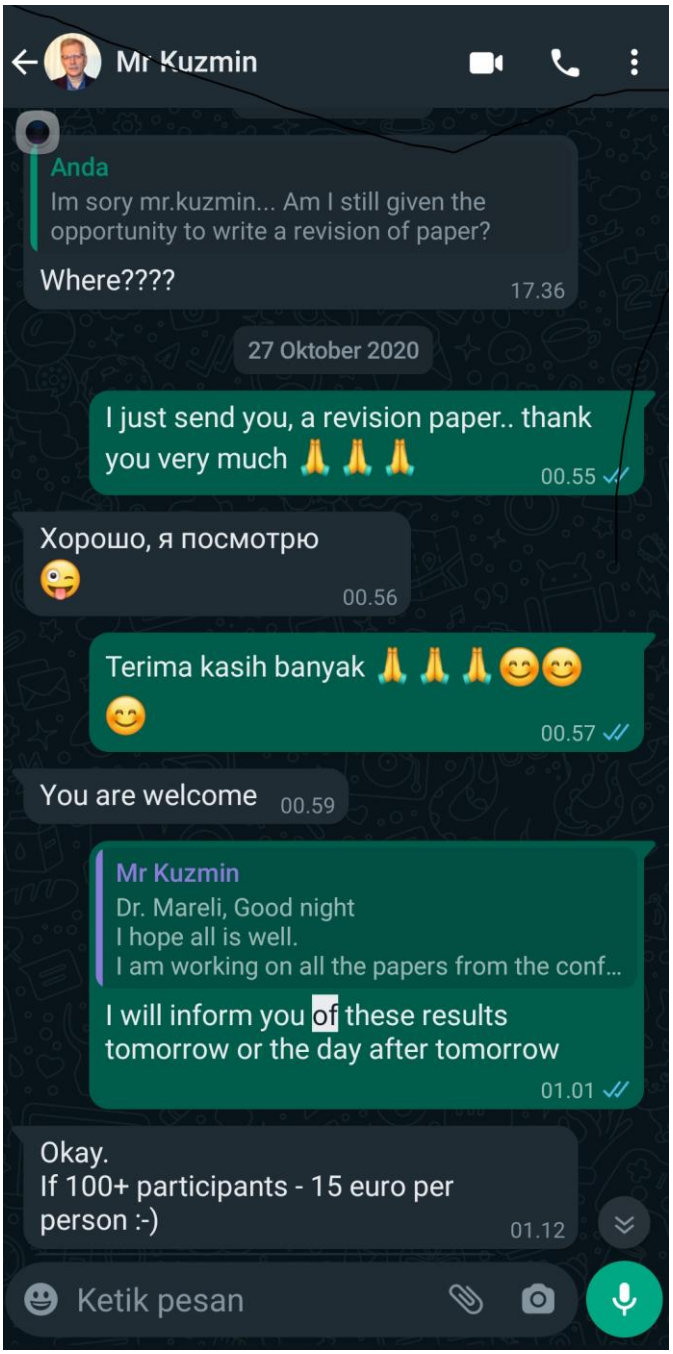
Bentuk Koresponding Tambahan Melalui Whatsapp kepada Editor Procedia Environment Science, Engineering Management.

Judul

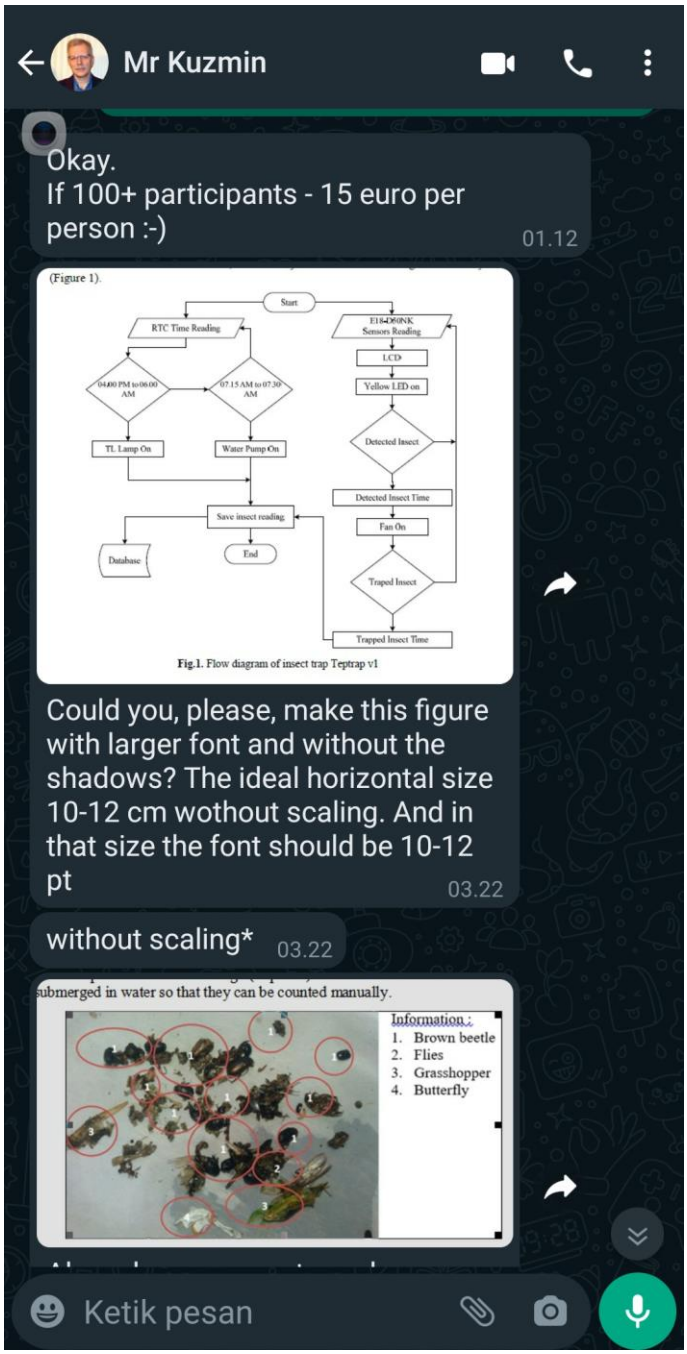
DESIGN OF INSECT TRAP AUTOMATIC CONTROL SYSTEM FOR CACAO PLANTS

13 September 2020

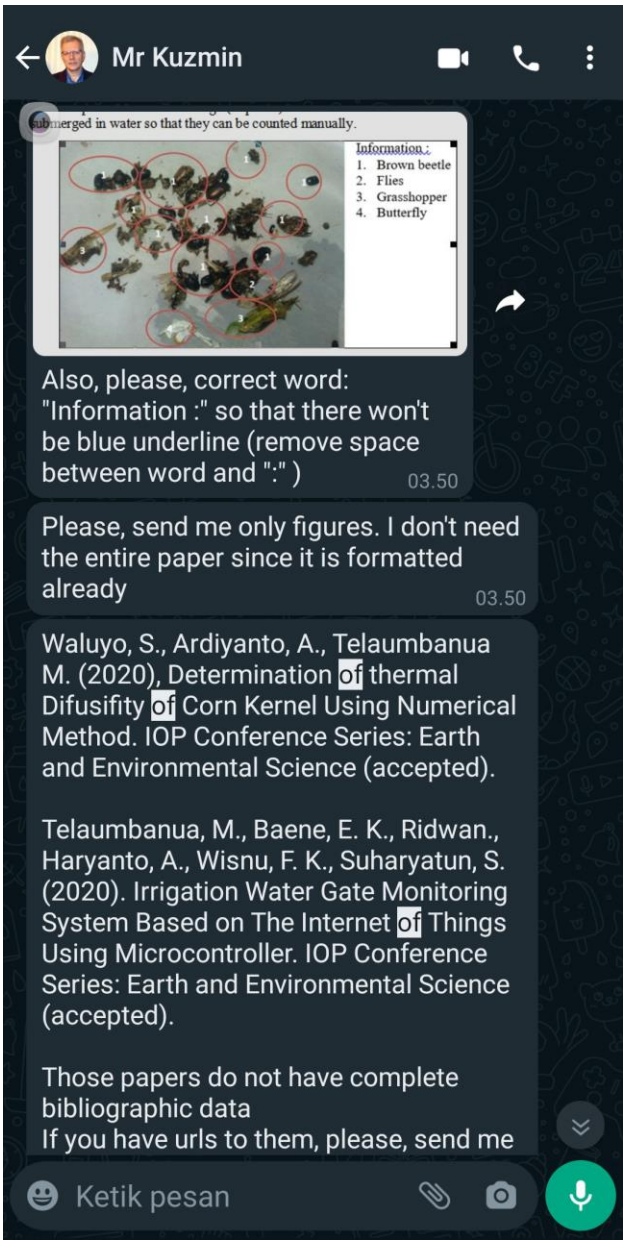
25 Oktober 2020



27 Oktober 2022



27 Oktober 2022



27 Oktober 2020

Certificate

of Attendance & Oral Presentation

Environmental innovations:

ADVANCES IN ENGINEERING, TECHNOLOGY AND MANAGEMENT

19-23 October, 2020

2nd International Online Conference

Dr. Mareli Telaumbanua

University of Lampung, Indonesia

Design of insect trap automatic control system for Cacao plants

Chairman Prof. Aleksandr Yudakov

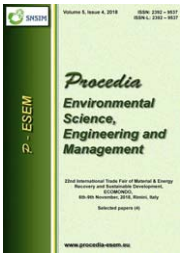
Chairman Prof. Dean Vučinić

Chairlady Prof. Valeriya Pinchuk

Scientific Chairman Dr. Andrey Kuzmin

Certificate No. **200511154433010**

“Environmental Innovations: Advances in Engineering, Technology, and Management”
II
September 21-25, 2020
http://environment.triacon.org/index.html



Dear Dr. Mareli Telaumbanua

On behalf of the Organizational Committee
I inform you that your paper

Design of insect trap automatic control system for cacao plants

was accepted by the Committee for presenting on the
International **Online Conference (eConference)** entitled:
"Environmental Innovations II:
Advances in Engineering, Technology, and Management"
21-25 September, 2020

http://environment.triacon.org/index.html

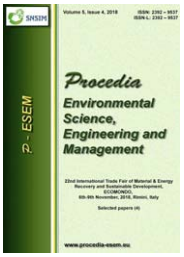
The paper will be published in the journal **“Procedia Environmental Science, Engineering and Management”** (indexed in Scopus) prior or soon after the conference term.

Faithfully yours,
Dr. Andrey V.Kuzmin

Scientific Chairman
03/27/2020

"Environmental Innovations: Advances in Engineering, Technology, and Management"
II
September 21-25, 2020

http://environment.triacon.org/index.html



Client: **University of Lampung**
Jl. Soemantri Brojonegoro, No. 1,
Bandar Lampung,
35145,
Indonesia

Date: **03/27/2020**

Registration Code: **EIAETM-II-/03/27/3020-0940/ID**

INVOICE* No. 1585291954

Payment purpose:	For registration concept of *Dr. Mareli Telaumbanua*
Presentation Title:	1. Design of insect trap automatic control system for cacao plants
Author(s):	Mareli Telaumbanua, Agus Haryanto, Febryan Kusuma Wisnu, Budianto Lanya, Wahyu Wiratama
Price per item:	200.00 Euro
Number of items:	1
Sum total:	200.00 Euro
Status:	paid
Payment method:	Google Pay / Card
Link to the payment page:**	https://secure.wayforpay.com/invoice/ic63668ffbb2f

*Invoice valid to: 04/03/2020
**Payment must be processed by secure card payment.

On behalf of Organizational Committee
Scientific Editor

Dr. Andrey Kuzmin
Scientific Chairman
03/27/2020

13:00 – 13:20 Baena-Moreno *(Local Time Spain 12:00 - 12:20)*

Keynote Lecture*

Opportunities for CO2 utilisation via carbonation

Francisco M. Baena-Moreno

Technical School of Engineering, University of Seville, Sevilla, Spain

This study focuses on describing the most important aspects of CO2 carbonation processes. Furthermore, a novel proposal for classifying CO2 carbonation alternatives is presented. The technologies are classified into two main categories: mineral CO2 carbonation; and hydroxides, salts and waste carbonation.

13:20 – 13:40 Martinus et al. *(Local Time: Indonesia 17:20 - 17:40)*

Development of Teak Leaf Plate Molding Machine for Producing Plastic Alternative Products

Martinus, Agus Haryanto, Sugeng Triono, Mareli Telaumbanua

University of Lampung, Bandar Lampung, Indonesia

Single use plastic is one of the biggest problem in the world right now, it is the main source of non-degradable material in the world. The usage of plastic and plastic derivatives in Indonesia most times cannot be avoided as long as no alternatives products are available. Only a small portion of the plastic is recycled, the rest end up in the land and in the ocean. Plastic need hundreds of year to decompose and some even can't decompose like expanded polystyrene. A new machine is in need for in producing an alternative product for plastic. This machine is designed, develop and fabricated in Indonesia. PID control system is used to control both upper and lower die. Set points for both die can be set individually. The temperature of upper and lower die varies by different leaves and how many layer of leaves. The leaf plates made by the machine then tested along with plastic plates, expanded polystyrene plates and plastic laminated paper plates. The result of this test will conclude how good the leaf plates as an alternative for other disposable plates. Teak leaf plate molding machine is built and performing quite well. The temperature from upper and lower die can be controlled precisely. The plates that produce by the machine in tensile strength test also perform quite well. Teak leaf plates tensile break average at 29.3 N, slightly lower than plastic one and higher than expanded polystyrene one.

13:40 – 14:00 Telaumbanua et al. *(Local Time Indonesia 17:40 - 18:00)*

Design of insect trap automatic control system for Cacao plants

Mareli Telaumbanua, Agus Haryanto, Febryan Kusuma Wisnu, Budianto Lanya, Wahyu Wiratama

University of Lampung, Bandar Lampung, Indonesia

Insect pests attacks on Cacao (Theobroma cacao L) plantations are generally controlled using chemical (non-organic) pesticides. Pesticides that are applied continuously can cause pest resistance, pest resurgence, and environmental pollution. Environmental pollution can disrupt the ecosystem due to increased toxic residues in plant tissue or the soil. Therefore, it is necessary to design a pest trap with charm and an automatic actuator based on a microcontroller on the Arduino board. This automatic insect trap is called the Teptrap v1. Five units of the infrared sensor type E18-D50NK are used to detect insect pests. The attractants used were TL lamps, yellow lights and attractants attached to the trap system. Teptrap v1 shows excellent performance during 33 days of research. As evidenced by the fan actuator system that works stably with a catching accuracy of 82.74%, insect drop time is 6 minutes 33 seconds, and the actuator response speed turns on the light, yellow LED and pumps <1 second (± 10 mS). This insect pest control trap can reduce the use of spray pesticides by 20-50%, thereby saving the cost of purchasing pesticides up to IDR 74,468 per hectare of Cacao.

---

* **Duration of the Keynote Presentations can be increased**

14:00 – 14:20 **Morais et al.** ***(Local Time Portugal 12:00 - 12:20)***

Development of a monitoring device for fruit products transportation in the cold chain

Diogo Morais, Martim L. Aguiar, Pedro D. Gaspar, Pedro D. Silva,

University of Beira Interior, Covilhã, Portugal
C-MAST - Centre for Mechanical and Aerospace Science and Technologies, Covilhã, Portugal

During food transport, products are often subject to conditions which do not benefit the conservation of their biological properties. This condition can lead to food quality and safety issues and ultimately to food waste. Globally, there was been an effort to develop techniques, procedures and technologies that can contribute to reduce food waste of perishable products such as horticultural ones. In this sense, remote monitoring systems, whose fundamental requirements relate to range and autonomy, make use of communications technologies to map characteristic crop parameters to reduce unnecessary application of resources or materials. This paper proposes a monitoring system to record the conservation conditions inside refrigeration plants and vehicles, transmitting them via the internet of Things (IoT). This device is composed of an ARDUINO UNO Rev3 microcontroller that acquires the environment temperature and relative humidity every 5 minutes by means of a DHT 11 sensor, and uses the SIM800L module that provides real time communication data via GSM. It also incorporates a 3.7 V – 2600 mAh battery that provides an approximate 60 hours power range.

14:20 – 14:40 **Aguiar et al.** ***(Local Time: Portugal 12:20 - 12:40)***

Testing of a resistive sensor with fabric medium for monitoring frost formation in refrigeration systems

Martim L. Aguiar, Pedro D. Gaspar, Pedro D. Silva,

University of Beira Interior, Covilhã, Portugal
C-MAST - Centre for Mechanical and Aerospace Science and Technologies, Covilhã, Portugal

Refrigeration is one of the key elements for food preservation. With global temperatures increasing due to global warming, the efficiency in refrigerated storage systems must be improved. One of the problems that is yet to be solved in these systems is the efficient and accurate removal of the frost formed on the heat exchanger surface. In previous works, a low-cost resistive sensor has been developed to detect frost formation for accurate removal. This paper shows the results of an experimental study carried out to increase the accuracy, by placing different configurations of a fabric medium in between the sensor electrodes.

14:40 – 15:00 **Kumar et al.** ***(Local Time Portugal 12:40 - 13:00)***

Experimental tests of the thermal behaviour of new sustainable bio-packaging food boxes

Sasi Kumar, Fábio Leitão, Pedro D. Gaspar, Pedro D. Silva,

University of Beira Interior, Covilhã, Portugal
C-MAST - Centre for Mechanical and Aerospace Science and Technologies, Covilhã, Portugal

This experimental task was performed using 8 sustainable Bio-Boxes in the thermal chamber in the laboratory. The air is forced from the refrigerator, and it is used to control the temperature inside the thermal chamber. The goal of the performed task is to evaluate the thermal behaviour of the bio Boxes made from different material, such as sugarcane bagasse and PLA material with respect to time. The test was performed to lower the temperature inside the chamber to its minimum air temperature inside the cold chamber. The results show that the SCB 4 has noticed changes in its mechanical properties (Tensile Strength) and it also shown some moisture absorbing when compared to other Bio boxes. Furthermore, this kind of Bio packaging materials needs more research to improve their mechanical and barrier properties and minimise the use of plastic containers for food packaging industry.

15:00 – 15:20 **Kryvenko** ***(Local Time Ukraine 15:00 - 15:20)***

Emissions of pollutants into the atmospheric air by stationary sources

Galyna Kryvenko

Ivano-Frankivsk National Technical University of Oil and Gas, Ivano-Frankivsk, Ukraine

Oil and gas companies are one of the main sources of man-made hazards associated with the emission of extremely harmful substances and extreme situations. Emissions of harmful substances during the operation of oil and gas facilities complicate the environmental situation. Environmental issues are always actual. The purpose of this work is to analyze the dispersion of pollutant emissions into the atmosphere by stationary sources. The research was addressing the issues of analysis of ground-level concentrations of pollutants within a sanitary protection zone. The object of the study is the enterprises of the oil and gas complex, the subject of the study is the estimation of emissions of harmful substances into the atmosphere by stationary sources. Emissions of pollutants were calculated using a Gaussian statistical model. Mathematical models for the determination of lateral and vertical diffusion coefficients were constructed. The analysis of pollutant emissions into the atmospheric air by stationary sources of different altitudes was performed. It is established that the concentration of the pollutant from the source decreases monotonically. The bulk of impurities is concentrated in a relatively narrow jet. The lower the source, the closer to it the maximum concentration of air pollutants is, resulting in a negative impact on the health of service personnel.

15:20 – 15:40 **Belokon et al.** ***(Local Time: Ukraine 15:20 - 15:40)***

Optimal composition of intermetallic catalyst for neutralization of carbon-containing components of gas emissions

Karina Belokon, Volodymyr Pohrebennyk, Artem Sybir, Yevheniia Manidina, Andrii Banakh

Zaporizhzhia National University, Engineering Educational and Research Institute, Zaporizhzhia, Ukraine
Lviv Polytechnic National University, Lviv, Ukraine
National Metallurgical Academy of Ukraine, Dnipro, Ukraine

The paper presents the results of the optimization of intermetallic compounds used for catalytic neutralization of carbon-containing exhaust gases. The statistical method of designing active experiments was used to analyze the effect of cobalt, manganese and copper on the catalytic, physical and chemical properties of the catalyst. The catalytic activity, specific surface area, and porosity of the catalyst were taken as the response function. The experimental data were mathematically processed using regression analysis. The work used a symmetric composition second-order design. As a result of mathematical programming, regression equations were obtained that describe the effect of the cobalt, manganese and copper content on the catalytic properties and porosity of the catalyst, and the response surfaces. The optimal combination of catalytic, physical and mechanical properties ensures that the compound contains 30% of nickel, 10% of cobalt, 11% of manganese and 2% of copper. When using such intermetallic compound, the conversion of carbon monoxide is 100%, and that of propane is 95 %, the specific surface area of the obtained catalyst is 110 m2/g, and the porosity is 64 %. The error of the regression equations did not exceed 2%.

15:40 – 16:00 **Mosiyevych et.al** ***(Local Time Ukraine 15:40 - 16:00)***

The physical and mechanical properties of intermetallic catalysts for the neutralization of carbon-containing components of emission gases

Karina Belokon, Yevheniia Manidina, Aleksandr Fedchenok, Andrii Banakh, Larysa Mosiyevych

Zaporizhzhia National University, Engineering Educational and Research Institute, Zaporizhzhia, Ukraine

The analysis of the study results of the physical and mechanical properties of intermetallic catalysts showed that they differ depending on their composition and processing method. The difference in the physical and mechanical properties of the catalysts is explained by differences in their structure, phase composition, porosity and pore size. When manganese is added, the porosity of the catalyst increases as a result of an increase in the volume of large pores while the structure of small capillaries does not change due to the localization of manganese oxide in the catalyst's pores. Yet, the mechanical strength decreases and can be increased if the copper alloy is added in the Ni-Co-Mn catalyst. A major benefit of thermal self-ignition is that the catalyst's strength is 50% higher than that of sintered materials with the same porosity. High temperatures of the process and low impurity content at the grain boundaries (due to self-cleaning) lead to the formation of strong bonds between grains in the crystallite. The average specific surface area for all investigated catalyst samples is 112 m2/g.

16:00 – 16:20 Manidina et al. ***(Local Time Ukraine 16:00 - 16:20)***

Using plasma catalysis for oxidation of sulphur dioxide to sulphur trioxide

Yevheniia Manidina, Karina Belokon, Nataliia Berenda, Olena Troitska

Zaporizhzhia National University, Zaporizhzhia, Ukraine

The paper researches the influence of the main properties of streamer discharge on the conversion of sulphur dioxide into sulphur trioxide and the effect of gas exposure to a streamer discharge for the oxidation of sulphur dioxide. It has been defined that the change of peak to peak voltage has the most impact on the efficiency of sulphur dioxide capture. It has been found out that delivery of voltage pulses with a period of 1ms allows having the conversion rate of sulphur dioxide at about 96.7%. It has been detected that with the pulse duration of 350 ns the conversion rate of sulphur dioxide is 98.6%.

16:20 – 16:40 Zhang ***(Local Time: USA 09:20 - 09:40)***

Keynote Lecture*

Membrane technologies for CO2 capture

Zhien Zhang

The Ohio State University

CO2, as a major greenhouse gas emission, has attracted the global attention. In order to achieve the CO2 reduction target by 2050, carbon capture technologies have been widely investigated all over the world. Membrane technology as an emerging approach is used to capture CO2. Compared with the conventional amine method, membrane technology provides modularity, flexibility and no flooding, foaming or entrainment. In this work, membrane gas absorption (MGA) technology is proved to capture more than 95% CO2 from the power plant flue gas. This technology shows great potentials to remove CO2 and other acidic gases from biogas, syngas, natural gas, and coalbed methane.

---

* **Duration of the Keynote Presentations can be increased**

14:00 – 14:20 **Zhelnovach et al.** ***(Local Time Ukraine 14:00 - 14:20)***

Researching the degradation of roadside plant communities

Ganna Zhelnovach, Karina Belokon, Yevheniia Manidina, InnaTkalich

Kharkiv National Automobile and Highway University, Kharkiv, Ukraine
Zaporizhzhia National University, Zaporizhzhia, Ukraine

Biodiversity loss is one of the global problems of mankind. The article studies the impact of the road use on biodiversity loss and, as a result, the degradation of plant communities which occupy large areas and are the basis of ecosystem development. It is defined that they degrade due to man-made soil salinisation, physical vegetation destruction, dust and chemical pollution. The paper assesses the level of such degradation of the roadside plant community at the representative road section in terms of quantity and quality. A significant level of destructive impact has been detected which results in the loss of species composition, displacement of glycophytes by halophytes, reduction of grass density by over 70 % compared to the checkpoint as the highway nears. Practical approaches to the development and implementation of a roadside vegetation management system are proposed.

14:20 – 14:40 **Triyono et al.** ***(Local Time Indonesia 18:20 - 18:40)***

Effects of organic compost doses and regulated irrigation on growth and yield of organic Red Rapid Lettuce (Lactuca sativa L var. Red Rapids)

Sugeng Triyono, Aldi Riski Wibowo, Dermiyati, Jamalam Lumbanraja

University of Lampung, Bandar Lampung, Lampung Province, Indonesia

Organic vegetables have gotten an increasing interest, but organic fertilizers and irrigation water used to produce them could be significant issues of economic calculation to be considered for some locations. This study was aimed to determine the optimum doses of organic compost and irrigation level for growing organic red lettuce in a greenhouse. Completely Random Design (CRD) coupled with factorial arrangement was implemented in this study. Treatments consisted of two factors; doses of organic compost (D) and regulated irrigation levels (I). The factor of doses included 0% (D0), 10% (D1), 30% (D2), and 50% (D3) organic compost of the total weight of the growth media (3 kg per pot). The factor of regulated irrigation levels included 40% (I1), 70% (I2), and 100% (I3) of available water. Three replicates were used, making total of 36 experimental units. Plants were cultivated in a greenhouse, using pots each of which contained 3 kg media, and watered regularly based on the treatments assigned. The data set was analyzed by using Analysis of Variance (ANOVA) and followed by least significant differences (LSD) at α= 5%. The result showed that Effect of interaction between organic compost doses and irrigation levels on the growth, yield, and water productivity of the red rapid lettuce was significant at $\alpha = 0.05$. However, the treatments were not significant on some chemical properties of the rapid red lettuce. The most optimum scheme was found to be the treatment combination between the organic compost dose of 300 g plant-1 (D1) and the regulated irrigation level at 100% (I3) of available water.

14:40 – 15:00 **Harahap et al.** ***(Local Time: Indonesia 18:40 - 19:00)***

Active versus passive cooling systems in increasing solar panel output

R. Harahap, S. Suherman

Universitas Sumatera Utara, Medan, Indonesia

Energy availability will remain an issue whole years as energy is the primary human need to live in this planet. Fossil energy is no longer the primary choice as its availability decreases every year, although it dominates the energy source used today. Solar cell is increasingly installed throughout the world even dough initial cost is still expensive for many developing and poor countries. For them who have connected the solar system generators to grid, sunlight to electrical conversion efficiency is the primary concern. On the other hand, system output optimization such as by using maximum power tracking method and cooling system are non material efficient solutions. Maximum tracking system may be costly as mechanical system should be developed well for large solar system. Cooling system on the other hand, is much simpler but limited in efficiency increment. Even dough, beside efficiency increment, the cooling system assists system to avoid excessive surface temperature, which in some cases may lead to panel destruction. The active cooling system requires some electric current from the solar panel output to enable cooling system works. The system achieves better surface temperature reduction than passive cooling system, but the current absorption should be as low as possible to avoid deficiency. This work proposed water based cooling system energized by batteries and compared the output performance to passive cooling system. The result shows that the periodic water sprinkler results better temperature decrement about 13.6% higher power than passive cooling system for sprinkler period of 20 minutes and sprinkle duration of 20 second. The performance decreases when sprinkler period is set 60 minutes. By using the applied water tank, water is available up to 24 hours for sprinkle period of 20 minutes but last longer for 60 minutes. Horizontal sprinkler position results larger cooled area than vertical position which generates 2.45% higher output power.

15:00 – 15:20 **Adoniev et al.** ***(Local Time Ukraine 15:00 - 15:20)***

Increasing the uniformity of metal heating in chamber furnaces by influence of the electric field

Andrii Cheilytko, Yevhen Adoniev, Alina Yerofieieva

Zaporizhzhia National University, Zaporizhzhia, Ukraine

The article is devoted to the possibility of increasing the energy of efficiency of gas chamber furnaces. For high-quality metal heating in a chamber furnace is proposed to use spatial electric field. It is empirically proved that there are optimal values of electric field control factors for chamber furnaces with a pull-out hearth, which reduce fuel consumption and produce quality of heating of metal, namely: high uniformity of heating.

15:20 – 15:40 **Yousef et al.** ***(Local Time Russia 15:20 - 15:40)***

Experimental investigation of a two-zone dry low emission gas turbine combustor

Wisam Yousef, Vitaliy Sychenkov, Nikolay Davydov, Vladislav Varsegov, Ruslan Khaliulin

A.N.Tupolev Kazan National Research Technical University – KAI, Kazan, Russia

A new design of a two-zone combustor with sequentially located pilot and main zones is described. The pilot zone provides: the required range of stable combustion at leaner conditions, heating and initiation of combustion in the main zone. The main zone provides burnout of the fuel-air mixture at leaner conditions with low emission values. Combustion in both zones is formed by supplying air through the double tangential swirlers with co-rotation in the pilot zone and counter-rotation in the main zone, while the fuel is supplied between the swirlers vanes. It is shown that the investigated combustor ensures the simultaneous minimization of emissions (CO and NOx) at acceptable values of non-uniformity of the outlet temperature field and a wide range of stable combustion.

15:40 – 16:00 **Evdokimov et al.** ***(Local Time: Russia 15:40 - 16:00)***

Emission characteristics of bidirectional vortex combustors operating on gaseous, liquid and pulverized solid fuel

Oleg Evdokimov, Alexander Guryanov, Sergey Veretennikov

Soloviev Rybinsk State Aviation Technical University, Rybinsk, Yaroslavl Region, Russia

The paper reports on a comparison of emission characteristics in the bidirectional vortex combustor operating on different types of fuel. Gaseous propane, liquid kerosene, and solid pulverized peat are suggested. It is shown that emission curves differ from classical ones corresponding to gas turbine combustion. Comparative analysis of the emission curves shows that NOx emission is similar for all three fuel types whereas CO emission differs significantly. The use of all types of fuel gives minima of CO emission for lean combustion. However, optimal ranges for solid and liquid fuel are smaller than for gas because of the strong influence of evaporation and devolatilization processes. Additionally, there is an increase in CO emission for kerosene and peat above the upper limit of the optimal λ range which corresponds to the most environmentally friendly combustion. CO emission for gaseous fuel remains minimal up to the lean flameout boundary.

16:00 – 16:20 **Isaza-Ruiz et al.** ***(Local Time Colombia 08:00 - 08:20)***

Thermal properties of hitec salt-based nanofluids synthesized by new two-step method

Marllory Isaza-Ruiz, Francisco Bolívar Osorio

Centro de Investigación, Innovación y Desarrollo de Materiales CIDEMAT, Medellín, Colombia

The use of molten salt-based nanofluids as a thermal storage medium, the evaluation of their thermophysical properties, and the development of new more efficient synthesis methods, have attracted great interest from researchers. In this way, this work focuses on the development of a new two-step method in which the use of water in the process is eliminated, without affecting the stability and homogeneity of the particles within the salt. Molten salt-based nanofluids with Hitec as base fluid and alumina nanoparticles as an additive in three different proportions 0.5, 1.0, and 1.5 wt% with a 13.6 nm nominal size. The thermal properties, melting point, specific heat capacity, and thermal stability were evaluated, as well as, the microstructural analysis to determine the good distribution of the nanoparticles in the salt. The increase of up to 14.6% of the specific heat of the molten salt-based nanofluids compared to the base salt, as well as the decrease in the

melting point without affecting the thermal stability demonstrate the viability of the proposed method for the synthesis of nanofluids for thermal energy storage in CSP plants.

16:20 – 16:40 **Guryanov et al.** ***(Local Time Russia 16:20 - 16:40)***

A study of multifuel bidirectional combustor

Alexander Guryanov, Oleg Evdokimov, Sergey Veretennikov, Marina Guryanova

Soloviev Rybinsk State Aviation Technical University, Rybinsk, Yaroslavl Region, Russia

The results of experimental studies of the multifuel liquid-gas combustion in the bidirectional vortex combustor are presented. Propane is used as gaseous fuel and kerosene is used as the liquid. The transition between fuels of the different states of matter and molecular mass defines a change in flame geometry and combustion zone length. Depending on the degree of the airflow expansion, the experimentally measured values of the lean limit of stable combustion correspond to the range of the air-fuel equivalence ratio from 3.3 to 7.0. Additionally, the bidirectional vortex combustor provides sufficient stability at the repetitive transitions "liquid-to-gas-to-liquid". Measured values of the total thermal power of the combustor at five consecutive transitions define a change in the total thermal power of no more than 3%.

16:40 – 17:00 **Kovalnogov et al.** ***(Local Time: Russia 17:40 - 18:00)***

Simulation of the processes of combined fuel combustion and analysis of harmful substances emission

Vladislav Kovalnogov, Ruslan Fedorov, Andrei Chukalin, Usama Mizher

Ulyanovsk State Technical University, Ulyanovsk, Russia

Prevention of further atmospheric air pollution and reduction of toxic substances emission is one of the goals of state policy in the field of energy. In this regard, the search for new solutions that prevent negative impact on the environment is one of the priority tasks for modern society. An alternative, but less efficient fuel compared to natural gas is biogas extracted from organic waste. The high content of carbon dioxide in biogas reduces the calorific value, while flame detachment from the burner is also observed. One of the promising options for reducing the negative impact of energy on the environment is the combined burning of natural gas and biogas. For the combined burning of natural gas and biogas in operating power-generating boiler, it is necessary to reconstruct the burner devices installed on them. For a high-quality reconstruction of burner devices, it is important to have theoretical data on the effect of combustion combinations on the content of toxic combustion products in the flue gases of power-generating boilers. In this paper, a turbulence model k – ε (realizable) is presented, which allows simulating the combustion process of a fuel-air mixture. The quantitative content of NOx, CO_2 in the products of combustion of fuel combinations - natural gas, biogas, natural gas / biogas is presented.

17:00 – 17:20 **Pérez et al.** ***(Local Time Colombia 09:00 - 09:20)***

Implementation of clean production in cups and dishes with coffee grounds

Daniel Alberto García Pérez, Hanleidy Ibarguen Zúñiga, Alex Aparicio Alvarado Díaz, Anderson Manuel Trespalacio González, David Alberto García Arango

Corporación Universitaria Americana, Barranquilla, Atlántico, Colombia

In this paper, a methodology for the sustainable creation of MDF-type products based on coffee beans is presented. This type of production must be profitable, sustainable and environmentally friendly. Therefore, the relationship between the biomass content and drying temperature of the medium density chipboard plates and the physical characteristics that have low time and constant drying pressure is determined. For this purpose, an experiment is carried out at the laboratory level to determine the relationship between biomass at different levels of binders in a percentage way with respect to coffee grounds, in specimens of a size already determined for experimentation. This process makes possible to determine possible differences in levels of similarity with respect to a wooden MDF pattern.

17:20 – 17:40 **Chernyavskyy et al.** ***(Local Time Ukraine 17:20 - 17:40)***

Scientific bases, experience of production and combustion of coal mixtures at thermal power plants of Ukraine

Mykola Chernyavskyy, Oleksii Provalov, Oleksii Kosyachkov, Igor Bestsennyy

Coal Energy Technology Institute (CETI) of National Academy of Sciences of Ukraine, Kyiv, Ukraine

It is substantiated that in conditions of termination of supplies of Donetsk anthracite the expansion of fuel base of anthracite power units, which make up half of generating capacities of thermal power plants (TPPs) of Ukraine, is possible due to use of mixtures of anthracite with local bituminous coal and petroleum coke. The issues of production, pulverizing, combustion of mixtures and environmental aspects of their use are considered. Based on the numerical analysis of the ratio of specific combustion rates of fuels, it is shown that 30-35% of bituminous coal significantly contribute to the ignition and combustion of anthracite in the pulverized coal flame. The criteria of homogeneity of mixtures are established and the methods of production and testing the homogeneity of mixtures at the TPP coal storage place are worked out. The experience of coal mixtures combustion at three power plants of Ukraine is generalized.

17:40 – 18:00 **Repelewicz et al.** ***(Local Time: Poland 16:40 - 17:00)***

Gypsum composites with woodchip and sawdust fillers

Aleksandra Repelewicz, Katarzyna Regulska

Czestochowa University of Technology, Czestochowa, Poland

Gypsum composites have been gaining increasing interest during last years. The focus on increasing their production in Poland results from the rich, countrywide natural gypsum sources and the growing amounts of synthetic gypsum derived from flue gas desulfurization in domestic power plants. Nowadays, the environment-supporting options are in game. Comparison of results of tests concerning the physical and mechanical properties of gypsum composites with organic fillers: wood sawdust and chips is described in the paper.

18:00 – 18:20 **Peceño et al.** ***(Local Time Chile 12:00 - 12:20)***

Influence of particle size of mussel shells in physical, mechanical and insulating properties of fireproof materials

Begoña Peceño, Bernabe Alonso-Fariñas, Celia Arenas, Carlos Leiva

Universidad Católica del Norte, Coquimbo, Chile
Universidad de Sevilla, Seville, Spain

In this study, the behavior of mussel shell as a component of passive fire protection materials was evaluated. To investigate the performance of mussel shell waste, different gypsum replacement ratios were analyzed from 40 to 80 %wt. Two different kinds of shells, separately or as a mix, were employed:. In addition, two different particle size distributions, smaller than 320 µm and bigger than 320 µm, were used. Physical, mechanical, insulating capacity and leaching properties were thoroughly analyzed. Our results indicate that replacements lower than 60 %wt comply with all mechanical demands and have no reduction in insulating capacity. Additionally, no leaching problems were detected. Mortars made by combination of mussel shell and gypsum have the potential to be used as a component in construction materials for passive protection against fire.

18:20 – 18:40 **Oliveira et al.** ***(Local Time Brazil 11:20 - 11:40)***

A new microbicidal pervious concrete pavement to be used in hospital parking-lots: assessment of the modulus of elasticity by the finite element method

Evailton Arantes de Oliveira, Justice Kofi Debrah, Maria João Correia de Simas Guerreiro, Maria Alzira Pimenta Dinis

University Fernando Pessoa, Porto, Portugal

In the coronavirus pandemic (COVID-19), it is important to articulate a safeguard against urban contamination originating from hospitals, mainly the tires of vehicles that travel in the hospital parking-lots and contaminating the various parts of the city through traffic on urban roads. With the purpose of disinfecting the pavement of hospital parking-lots to prevent diseases, this research proposes the use of a new pavement composed of pervious concrete

with calcium hydroxide (Ca(OH)2) additive, i.e., lime powder. The well-known powder lime becomes a disinfectant with a microbicidal effect which increases the pH of the pavement, being a low cost and an abundant material. Studies have shown that this additive affects the mechanical strength of pervious concrete when added to its mixture. Accordingly, the objective of the study is to find a balance between mechanical strength and the ideal proportion of lime powder additive in the pervious concrete mixture through finite element prototypes subjected to vertical loads of 10,000 N with variation in the modulus of elasticity. The results of the structural simulations indicate the prototype with the best performance ratio is 1:0.8:4 (cement:Ca(OH)2:limestone), compressive strain of 15.70 kg/cm2, density of 1,971.42 kg/m3 and modulus of elasticity of 1,480.22 MPa, with demonstrates a satisfactory mechanical performance for the use of this new pavement in hospital parking-lots.

18:40 – 19:00 **Guryanov et al.** ***(Local Time: Russia 18:40 - 19:00)***

The structure of nonreactive bidirectional and direct swirling flows and its effect on mass transfer intensification and mixing efficiency

A.I. Guryanov, A.V. Kosonogova, M.M. Guryanova, O.A. Evdokimov, S.V. Veretennikov

Soloviev Rybinsk State Aviation Technical University, Rybinsk, Yaroslavl Region, Russia
Public JSC "UEC-Saturn", Rybinsk, Yaroslavl Region, Russia

One of the most promising methods of low-emission methane combustion is in a lean fully pre-mixed flame. A key characteristic of such an (non-stoichiometric) approach is the ability to directly control the air-to-fuel ratio. This can be achieved in the pre-mixing stage of fuel and oxidizer. The focus of the present paper is to study uniformity of fuel distribution in fully pre-mixed flame module of a concept lean bi- and mono-directional fuel- and air-flow combustion chamber. Numerical and experimental studies of fuel and air mixing have been carried out. Four configurations were considered, differing in presence/absence of flow swirl and relative flow directions of mixing components. It is found that the configuration with highest mix uniformity is one with bi-directional swirling air-flow with respect to injected fuel.

19:00 – 19:20 **Moumane et al.** ***(Local Time Ukraine 19:00 - 19:20)***

Specifics of coal-water fuel heat transfer at the fuel pre-heating stage

Valeriya Pinchuk, Mohammed Moumane, Tatiana Sharabura, Yulia Shishko, Andrey Kuzmin

National Metallurgical Academy of Ukraine, Dnipro, Ukraine
Institute for Engineering Thermal Physics of National Academy of Sciences of Ukraine, Kiev, Ukraine

Renewable energy sources are currently unable to meet the growing energy demand. Therefore, fossil fuels are continued using for energy generation. Coal is one of the most used resources for this purpose. However, its combustion leads to huge environmental pollution. The usage of coal in the form of coal-water fuel allows significantly decreasing the volume of harmful emissions. Scientific research in this area became of high-interest last decade. The usage of coal-water fuel requires some preparations and activation of the fuel before combustion. One of the preparation stages is coal-water fuel's thermal activation which improves the burning processes of such a fuel. This manuscript considers specifics of the coal-water fuel pre-heating in the feeding pipe. The results show that wide used Graetz solution for Newtonian fluids cannot be used for calculation of the heat-transfer parameters in the case of coal-water fuel. An empirical equation was obtained for use in practical applications

---